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7 North Dixie Highway
Lake Worth Beach, FL 33460
561.586.1600

AGENDA
CITY OF LAKE WORTH BEACH
SPECIAL CITY COMMISSION MEETING - ARTIFICIAL TURF & TREE PLANTING
CITY HALL COMMISSION CHAMBER
THURSDAY, MAY 09, 2024 - 6:00 PM

ROLL CALL:

PLEDGE OF ALLEGIANCE: led by Commissioner Christopher McVoy

UNFINISHED BUSINESS:

A. Discussion of the RFQ for the Development Professional Services for the Lake Worth Beach Municipal Beach Complex

B. Discussion regarding the use of Artificial Turf

NEW BUSINESS:

A. Scope of Services for tree planting services recommended by the Tree and Landscape Board

ADJOURNMENT:

The City Commission has adopted Rules of Decorum for Citizen Participation (See Resolution No. 13-2023). The Rules of Decorum are posted within the City Hall Chambers, City Hall Conference Room, posted online at: https://lakeworthbeachfl.gov/government/virtual-meetings/, and available through the City Clerk's office. Compliance with the Rules of Decorum is expected and appreciated.

If a person decides to appeal any decision made by the board, agency or commission with respect to any matter considered at such meeting or hearing, he or she will need a record of the proceedings, and that, for such purpose, he or she may need to ensure that a verbatim record of the proceedings is made, which record includes the testimony and evidence upon which the appeal is to be based. (F.S. 286.0105)

REQUEST FOR QUALIFICATIONS

RFQ # 24-XXX

Lake Worth Beach - Municipal Beach Complex Development Professional Services

Financial Services
Procurement Division
7 North Dixie Highway
Lake Worth Beach, FL 33460
561.586.1770

RFQ # 24-XXX

Lake Worth Beach - Municipal Beach Complex Development

Professional Services

The City of Lake Worth Beach (the "City") is seeking qualifications from interested professional consulting companies/firms regarding the development of the City's Municipal Beach Complex. The City is seeking to hire a consultant to provide advice, evaluate location feasibility, develop potential options for the facility and property and lead the City through the process of planning and implementation of the future development for the Casino complex and pool located in the City of Lake Worth Beach.

The services consist of the site and building assessment activities, development of potential activities, real estate feasibility and budgeting activities, community/stakeholder outreach activities, solicitation and contract negotiation activities, and other related services.

Time is of the essence and any proposal received after **3:00 p.m., XXXXX, 2024,** whether by mail or otherwise will be returned unopened. Qualifications shall be placed in a sealed envelope, marked with the RFQ number, title, and date and hour Qualifications are scheduled to be received. Respondents are responsible for insuring that their Qualifications are delivered and stamped by the City's Financial Services Office personnel by the deadline indicated. The City reserves the right in its sole discretion to reject any or all Qualifications and/or to waive all nonmaterial irregularities on any and all Qualifications. All costs and expenses, including reasonable attorney's fees, incurred by any firm in preparing and responding to this RFQ are the sole responsibility of the respondents including without limitation any and all costs and fees related to a protest.

Interested persons or entities may obtain a copy of the RFQ by contacting the Financial Services office at (561) 586-1770 or from **lakeworthbeachfl.bidsandtenders.net**. All Respondents shall have a Bidding System Vendor account and be registered as a Plan Taker for this solicitation opportunity, which will enable the Respondent to download the Bid Call Document, to receive addenda, email notifications, and download all documents.

To ensure receipt of the latest information and updates via email regarding this solicitation, or if a Respondent has obtained this solicitation from a third party, the onus is on the Respondent to create a Bidding System Vendor account and be register as a Plan Taker for this solicitation opportunity.

All Qualifications must be hand-delivered or mailed to:

City of Lake Worth Beach
Financial Services, Procurement Division
7 North Dixie Hwy

Lake Worth Beach, FL 33460

ENVELOPE MUST BE IDENTIFIED AS: **RFQ # 24-XXX**

PUBLISHED: ~~April~~ May XX, 2024, Palm Beach Post, City's Website

GENERAL INFORMATION

1. PROJECT OBJECTIVE

The City of Lake Worth Beach (the "City") has a magnificent, one of a kind, nineteen-acre public beach site that has long been seen to be underutilized and full of potential and opportunities. Over the past decade plus, the City has struggled with what the future of the abandoned municipal pool will be as well as what is the acceptable and feasible amount of development for the site that meets with the expectations and tolerances of the general public, the true stakeholders of the unique resource.

To that end, the City is seeking qualifications from interested professional consulting companies/firms to provide advice, evaluate locations feasibility, develop potential options for the facility and lead the City through the process of planning the development for the Casino complex and pool located within the City of Lake Worth Beach.

The City's objective with this solicitation is to assess the overall current condition of the beach complex site, its operations and its future development potential, including strengths, weaknesses, opportunities and threats (SWOT). The resource is critically important to the City, its citizens and visitors to the city and region. Obtaining a complete and thorough understanding of its existing standing and the options available to improve its functioning, its financial feasibility and its realistic development potential is needed in order to identify parameters necessary for the site to be a sustainable recreational asset and resource for current and future generations.

The selected Respondent will be chosen based upon their relevant expertise and thorough knowledge of the professional services, functions, activities, and related responsibilities to successfully deliver required services. A more detailed scope of services is attached and incorporated into this RFQ as **Exhibit "A".**

2. SUBMITTAL OF QUALIFICATIONS

Interested firms are invited to submit a complete set of Qualifications for consideration. The Qualifications must address the items requested, clearly and concisely. The City intends to negotiate a contract/s for the desired services upon selection of the Qualifications that best satisfy the evaluation criteria.

Time is of the essence and any Qualifications received after **3:00 p.m., May XX, 2024** whether by mail or otherwise will be disqualified from consideration. **The City offices have limited access to the public at this time. Courier deliveries SHALL NOT require signature for the receipt. Respondents may deliver Qualifications directly to City Hall during regular business hours 8 a.m. to 5 p.m. Monday through Friday. If Qualifications are delivered in person, visitors shall ring the bell at the City Hall front entrance and wait for assistance or by contacting Procurement Division at (561) 586 – 1770 in advance.** The City will in no way be responsible for delays caused by any occurrence. **Qualifications shall not be submitted and will not be accepted by telephone, telegram, facsimile or e-mail.** Each envelope will be stamped by the Finance Office personnel with the date and time received. The time of receipt shall be determined by the time clock located in the Financial Services Office. Qualifications shall be placed in a sealed envelope, marked with the **RFQ number, title, type of category**, and date and hour Qualifications are scheduled to be received. **Respondents are responsible for ensuring that their Qualifications are delivered to Financial Services address by the deadline indicated.**

The City reserves the right in its sole discretion to reject any or all Qualifications and/or to waive all nonmaterial irregularities on any and all Qualifications. All costs and expenses, including reasonable attorney's fees, incurred by any Respondent in preparing and responding to this RFQ are the sole responsibility of the Respondent including without limitation any and all costs and fees related to a protest. The documents included or incorporated in this RFQ constitute the complete set of instructions, scope of work, specification requirements and forms. It is the responsibility of the Respondent to ensure that all pages are included. Therefore, all Respondents are advised to closely examine this RFQ. All Qualifications must be typed or written in ink, and must be signed in ink by an officer having authority to bind the Respondent. Signatures are required where indicated; failure to do so may be cause for rejection of the Qualifications.

3. CHANGES AND INTERPRETATIONS

Changes to this RFQ will be made by written addendum. A written addendum is the only official method whereby interpretation, clarification or additional information can be given.

All questions regarding this RFQ should be submitted in the bidding system at **lakeworthbeachfl.bidsandtenders.net or** *via e-mail to purchasing1@lakeworthbeachfl.gov not later than fifteen (15) calendar days prior to the due date for Qualifications.* Questions will be answered via an addendum. If a question is not answered, the Respondent should assume all relevant information is contained within this RFQ. The City will attempt to not issue any addenda within three (3) business days of the due date of Qualifications; however, the City reserves the right to issue any addenda at any time prior to the due date and time of Qualifications.

4. PROPERTY OF THE CITY

All materials submitted in response to this RFQ become the property of the City. The City has the right to use any or all ideas presented in any response to this RFQ, whether amended or not, and selection or rejection of a Respondent's Qualifications does not affect this right. No variances to this provision shall be accepted.

5. RFQ TIMETABLE

The anticipated schedule for this RFQ and contract approval is as follows:

- Questions from Potential Respondents Due — XXXXXX, 2024 (4 PM)
- Qualifications Due — xxxxxxxxxx, 2024 (3 PM)
- Evaluation/Short List Announcement — xxxxxxxx, 2024
- Discussions/Presentations — xxxxxxxx, 2024
- Contract Negotiations & Approval — xxxxxxxx, 2024
- Contract Start — xxxxxxxx, 2024

The City reserves the right to amend the anticipated schedule as it deems necessary.

6. CONE OF SILENCE

In accordance with the Palm Beach County Lobbyist Registration Ordinance and the City's procurement code, the City's procurement cone of silence will be in effect as of the deadline to submit Qualifications in response to this RFQ. A complete copy of the City's procurement code is available on-line at municode.com under the City's code of ordinances (sections 2-111 – 2-117).

All Respondents are highly encouraged to review the same. In summary, the cone of silence prohibits communication between certain City officials, employees and agents and any entity or person seeking to be awarded a contract (including their lobbyists and potential subcontractors). The cone of silence terminates at the time of award, rejection of all responses or some other action by the City to end the selection process.

7. ETHICS REQUIREMENT

This RFQ is subject to the State of Florida Code of Ethics and the Palm Beach County Code of Ethics. Accordingly, there are prohibitions and limitations on the employment of City officials and employees and contractual relationships providing a benefit to the same. Respondents are highly encouraged to review both the Florida Code of Ethics and the Palm Beach County Code of Ethics to ensure compliance with the same.

Further, any Respondent coming before the City Commission for an award of a contract and who has made an election campaign contribution in an amount that is more than one hundred dollars ($100.00) to any elected official of the City Commission, who is a current sitting member of the Commission, must disclose such election campaign contribution, verbally and in writing, in their responsive proposal to this RFQ. Therefore, all Respondents shall complete the City's Campaign Contribution Statement attached to this RFQ as Exhibit "E".

8. DISCLOSURE AND DISCLAIMER

The information contained herein is provided solely for the convenience of Respondents. It is the responsibility of the Respondent to assure itself that the information contained herein is accurate and complete. Neither the City, nor its advisors provide any assurances as to the accuracy of any information in this RFQ. Any reliance on the contents of this RFQ, or on any communications with City representatives or advisors, shall be at each Respondent's own risk. Respondents should rely exclusively on their own investigations, interpretations, and analyses in connection with this matter. The RFQ is being provided by the City without any warranty or representation, express or implied, as to its content, accuracy, or completeness and no Respondent or other party shall have recourse to the City if any information herein contained shall be inaccurate or incomplete. No warranty or representation is made by the City that any Qualifications conforming to these requirements will be selected for consideration, negotiation, or approval.

In its sole discretion, the City may withdraw this RFQ either before or after receiving Qualifications, may accept or reject Qualifications, and may accept Qualifications which deviate from the non-material provisions of this RFQ. In its sole discretion, the City may determine the qualifications and acceptability of any firm or firms submitting Qualifications in response to this RFQ. Following submission of Qualifications, the Respondent agrees to promptly deliver such further details, information and assurances, including, but not limited to, financial and disclosure data, relating to the Qualifications and/or the Respondent, including the Respondent's affiliates, officers, directors, shareholders, partners and employees, as requested by the City. Any action taken by the City in response to Qualifications made pursuant to this RFQ or in making any award or failure or refusal to make any award pursuant to such Qualifications, or in any cancellation of award, or in any withdrawal or cancellation of this RFQ, either before or after issuance of an award, shall be without any expense, liability or obligation on the part of the City, or their advisors.

Any recipient of this RFQ who responds hereto fully acknowledges all the provisions of this Discloser and Disclaimer and agrees to be bound by the terms hereof. Any Qualifications

submitted pursuant to this RFQ is at the sole risk and responsibility of the Respondent submitting such Qualifications.

9. CONTRACT AGREEMENT / COMPENSATION

The terms and conditions of the resulting non-exclusive contract(s) including the fees for the services to be rendered will be negotiated with successful Respondent using the City's contract form. If the City and the successful Respondent cannot agree on the terms and conditions of the resulting contract, the City reserves the right to terminate negotiations with the successful Respondent and move to the next ranked Respondent to commence negotiations. Negotiations may continue in this process until the City is able to enter into a contract with a Respondent that best meets the needs of the City consistent with the evaluation criteria.

Any contract executed as a result of this RFQ may be funded, in whole or in part, by Federal agencies. Respondents therefore agree that any work performed pursuant to this RFQ and resulting contract will comply with all applicable Federal law, Federal regulations, executive orders, Federal policies, procedures, and directives.

Each fiscal year of the contract and any future years will be subject to the availability of funds lawfully appropriated for its purpose by the City of Lake Worth Beach. The City need not include a lack of appropriations provision in the resulting contract to avail itself of such legal right.

10. INSURANCE REQUIREMENTS

Prior to execution of the resulting contract derived from this RFQ, the awarded Respondent shall obtain and maintain in force at all times during the term of the resulting contract insurance coverage as required herein. All insurance policies shall be issued by companies authorized to do business under the laws of the State of Florida. The Certificates shall clearly indicate that the firm has obtained insurance of the type, amount, and classification as required for strict compliance with this provision and that no material change or cancellation of the insurance shall be effective without thirty (30) days prior written notice to the City. Compliance with the foregoing requirements shall not relieve the selected Respondent of its liability and obligations under the resulting contract.

A. The selected firm shall maintain during the term of the contract, standard Professional Liability Insurance in the minimum amount of $1,000,000.00 per occurrence.

B. The selected firm shall maintain, during the life of the contract, commercial general liability, including public and contractual liability insurance in the amount of $1,000,000.00 per occurrence ($2,000,000.00 aggregate) to protect the firm from claims for damages for bodily and personal injury, including wrongful death, as well as from claims of property damages which may arise from any operations under the contract, whether such operations be by the firm or by anyone directly or indirectly employed by or contracting with the firm.

C. The selected firm shall carry Workers' Compensation Insurance and Employer's Liability Insurance for all employees as required by Florida Statutes.

D. The selected firm shall maintain comprehensive automobile liability insurance in the minimum amount of $1,000,000 combined single limit for bodily injury and property damages liability to protect from claims for damages for bodily and personal injury, including death, as well as from claims for property damage, which may arise from the

ownership, use, or maintenance of owned and non-owned automobiles, including rented automobiles whether such operations be by the firm or by anyone directly or indirectly employed by the firm.

All insurance, other than Professional Liability and Workers' Compensation, to be maintained by the selected Respondent shall specifically include the City as an "Additional Insured" on a primary and non-contributory basis.

11. E-VERIFY

Pursuant to Section 448.095(5), Florida Statutes, the successful bidder shall:

1. Register with and use the E-Verify system to verify the work authorization status of all newly hired employees and require all subcontractors (providing services or receiving funding under the resulting contract) to register with and use the E-Verify system to verify the work authorization status of all the subcontractors' newly hired employees;
2. Secure an affidavit from all subcontractors (providing services or receiving funding under the contract) stating that the subcontractor does not employ, contract with, or subcontract with an unauthorized alien;
3. Maintain copies of all subcontractor affidavits for the duration of the contract;
4. Comply fully, and ensure all of its subcontractors comply fully, with Section 448.095, Florida Statutes;
5. Be aware that a violation of Section 448.09, Florida Statutes (Unauthorized aliens; employment prohibited) shall be grounds for termination of the contract; and
6. Be aware that if the City terminates the contract under Section 448.095(5)(c), Florida Statutes, the bidder may not be awarded a public contract for at least 1 year after the date on which the contract is terminated and will be liable for any additional costs incurred by the City as a result of the termination of the contract.

12. EVALUATION AND AWARD

The evaluation and award of the submitted Qualifications shall be consistent with Florida's Consultants' Competitive Negotiations Act (CCNA) (section 287.055, Florida Statutes**).** The City will assemble an Evaluation Committee to review the submitted Qualifications and determine which Respondents are deemed "qualified" consistent with the Qualification Evaluation Criteria set forth herein. The City reserves the right to assemble different evaluation committee if found to be in the best interest of the City. The Evaluation Committee(s) will rank the Respondents and engage in discussions with no fewer than the top three (3) ranked Respondents regarding their Qualifications, approach to the project and ability to furnish the required services. The discussions may be in a presentation format before the Evaluation Committee at a public meeting or by written responses to follow-up questions from the Evaluation Committee or some other process established by the Evaluation Committee. After discussions, the Evaluation Committee shall rank the top qualified Respondents based on the Competitive Selection Evaluation Criteria herein and make a recommendation to the City Commission. City staff may negotiate with the highest ranked Respondent(s) to prepare a contract to be submitted with the Evaluation Committee's recommendation to the City Commission. The Procurement Representative will notify all submitting Respondents and notice the Evaluation Committee meeting(s) as directed by law. The City Commission is not bound by the recommendation of the Evaluation Committee and the City Commission may deviate from the recommendation in determining the best overall Qualifications which are most advantageous and in the best interest of the City (consistent with the selection evaluation criteria). Recommended award will be made available by the Financial Services Department Procurement Division electronically at **lakeworthbeachfl.bidsandtenders.net**.

Each submitted Qualifications will be evaluated individually and in the context of all other Qualifications. Qualifications must be fully responsive to the requirements described in this RFQ and to any subsequent requests for clarification or additional information made by the City through written addenda to this RFQ. Qualifications failing to comply with the submission requirements, or those unresponsive to any part of this RFQ, may be disqualified. There is no obligation on the part of the City to award to the most qualified, and the City reserves the right to award the contract(s) to the Respondent submitting the best overall Qualifications and in the best interest of the City (consistent with the evaluation criteria and successful negotiations). The City shall be the sole judge of the Qualifications and the resulting contract that is in its best interests.

As part of the evaluation process, the City may conduct an investigation of references, including but not limited to, a record check of consumer affairs complaints. By submitting Qualifications, Respondents acknowledge this process and consent to the City's investigation. City is the sole judge in determining the Respondent's qualifications.

While the City allows Respondents to specify any desired variances to the RFQ terms, conditions, and specifications, the number and extent of variances specified will be considered in determining the Qualifications which are most advantageous to the City.

Please be advised that pursuant to Section 287.05701, Florida Statutes, the City may not request documentation of or consider a consultant's social, political, or ideological interest when determining if the consultant is responsible. Further, the City may not give a preference to a consultant based on the consultant's social, political, or ideological interests.

Evaluation Scoring Criteria:

The evaluation of the Qualifications will be conducted in accordance with the following criteria (with associated points available).

Qualification Evaluation Criteria (Short-Listing)	**Points Available**

Evidence of personnel availability, capability, experience, and skill: 20 points

Emphasis will be placed on A) firm's identification of specific individuals in its employ, and/or subconsultants, B) individuals and/or subconsultants experience with similar projects within the past ten years.

Firm's successful past performance for similar projects & approach: 20 points

Individuals and/or subconsultants ability to have completed similar projects on time and within budget. Firms experience in multiple phases and similar developments/municipalities. Respondents will be evaluated on the firms' means and methods to accomplish multiple projects, community outreach, professional engineering services, solicitation and contract negotiation process, work with developers and commercial entities, presentations for the City and community. Quality of work, meeting technical requirements, completeness of deliverables with minimal revisions will be included in evaluation.

Project Approach and Methodology: 20 points

Respondents shall provide a comprehensive proposed project approach addressing all the required services as provided in this solicitation. The proposal shall clearly provide methodology and approach for the recommended steps of the project that will be completed, proposed deliverables and timelines. The emphasis will be given to proposals that provide detailed and innovative strategies and that demonstrate knowledge of the project and capability to meet the project requirements.

Client Management and Project Staffing Plan: 25 points

Respondents will be evaluated on how key team members/staff proposed for this engagement, including a Client Manager, Project Manager, and other Key Team Members will execute the work and take ownership of maintaining proactive and strategic communication with the working group and Lake Worth Beach staff and City Commission, as appropriate. Location and convenience to the City of Lake Worth Beach to support the projects will also be considered.

Terminations and/or litigation: 5 points

- Instances of a default under a similar project or contract;
- Instances of litigation related to a similar project or contract;
- Instances of on any debarment by a local, state or federal governmental entity

Evidence of veteran business enterprise, small business and local business preference: 5 points

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Maximum 100 Points

Oral presentation Criteria (to finalize ranking/recommendation):

Ability of professional personnel 20 points

Respondents will be evaluated on how their presentation provided for key team members/staff proposed for this engagement, including a Client Manager, Project Manager, and other Key Team Members and how will they execute the work and take ownership of maintaining proactive and strategic communication with the working group and Lake Worth Beach staff, as appropriate

Evidence of successful past performance for similar projects 20 points

Respondents will be evaluated on how their past performance on similar projects has prepared them for the diverse portfolio of the City and how they managed their past projects. The City will also look for any benefits and value added services that Respondents can provide to the City.

Comprehensive Project Approach and Methodology: 30 points

Respondents will be evaluated based on their proposed project approach addressing all the required services as provided in this solicitation. The City will look into the proposed methodology and approach and recommended steps, proposed deliverables and timelines.

Recent, current workload **10 points**

Respondents will be evaluated on their current work load and their presentation to show ability to meet the City's projects in the required timelines.

Location/Convenience to City staff **10 points**

Respondents will be evaluated on their ability to provide the support to the City of Lake Worth Beach by providing locally available professional staff or ability to provide the equivalent services in remote environment without additional fees.

13. QUALIFICATIONS FORMAT

Each Respondent shall submit **one (1) original, five (5) copies** of its Qualifications in a clear, concise format, on 8 1/2" x 11" paper, in English and **one (1) electronic copy (maximum size of 15MB) on USB drive**. Each tabbed set shall contain all the information required herein to be considered for award. Omission of required data may be cause for disqualification. Any other information thought to be relevant, but not applicable to the enumerated sections, should be provided as an appendix to the Qualifications. If publications are supplied by a Respondent to respond to a requirement, the Qualifications should include a reference to the document number and page number. Qualifications not providing this reference will be considered to have no reference materials included in the additional documents.

Qualifications must be properly signed in ink by the owner/principal having the authority to bind the firm to a resulting contract. **Signatures are required where indicated; failure to do so shall be cause for rejection of Qualifications.**

Qualifications which do not contain or address key points or sufficiently document the requested information may be deemed non-responsive.

All Qualifications shall be submitted in the format identified below. Failure to submit the required documentation in the format identified may cause for disqualification.

Tab 1 . Letter of Transmittal (< four pages)

This letter will summarize in a brief and concise manner the following:

- Entity name, address, telephone, website, email, and fax number (also on **Exhibit "B"**)
- Ownership/organization structure
- Parent company, if applicable
- Names of officers and principals
- The legal status and years of continuous operation
- In-house capabilities and services
- General summary of Respondent's business operation; how long in business; general approach to tasks and projects; and, why the Respondent should be selected, including a summary of relevant experience, accomplishments, and capabilities.
- Respondent's understanding of the Project and proposed Project option(s).

- The letter must name all persons or entities interested in the proposal as principals. Identify all of the persons authorized to make representations for the Respondent, including the titles, addresses, and telephone numbers of such persons.
- An authorized agent of the Respondent must sign the Letter of Transmittal and must indicate the agent's title or authority.
- The individual or firm identified on the Letter of Transmittal will be considered the primary firm. The firm will need to name the representative authorized to negotiate with the City.
- If more than one firm is named on the Letter of Transmittal, a legal document showing the partnership, joint venture, corporation, etc. shall be submitted showing the legality of such. Submittal for Joint Venture to include executed Joint Venture agreement and if state law requires that the Joint Venture be registered, filed, funded, or licensed prior to submission of the proposal, then same shall be completed prior to submittal. Respondents shall make their own independent evaluation of the requirements of the state law.

Tab 2 . Addenda (unlimited pages)

This section shall include a statement acknowledging receipt of each addendum issued by the City. Each Respondent is responsible for visiting ***lakeworthbeachfl.bidsandtenders.net*** to view and obtain each addendum. The City is not responsible for notifying potential respondents that the Addendums have been posted.

Tab 3. References & Materials (< 15 pages plus the forms)

Evidence of personnel capability, experience and skill: Respondents shall provide a brief overview of its personnel's capability, experience and skill to provide the requested services (which shall not exceed two pages per person) and include the firm's organizational structure. Bullet point format is appreciated. Respondents shall provide summaries or resumes of key personnel including those to be assigned to provide services to the City. Resumes should include a description of:

- Training, education and degrees.
- Similar project experience.
- Professional certifications, licenses and affiliations.

Evidence of adequate personnel to perform: Please identify key personnel who will be tasked to provide services to the City and their availability.

Tab 4 . Similar Projects & Approach (< 15 pages)

Evidence of firm's successful past performance for similar projects: Using the reference form provided, Respondents shall identify successful past performance for similar projects within the past five (5) years. Respondents shall provide a minimum of three (3) references on the form provided demonstrating their successful past performance. Prior experience with other Florida entities is desirable but not required. Similar projects may be coastal oriented redevelopment, historic revitalization, downtown redevelopment, brown field assessment and analysis, revitalization of recreation or community centers or facilities or similar related projects. Respondents are responsible for verifying correct phone numbers and contact information

provided. Failure to provide accurate information may result in the reference not being obtained or considered.

Provide evidence of firm's quality of work and ability to produce construction documents that meet technical requirements and codes.

Tab 5. Client Management and Project Staffing Plan (< 5 pages)

Provide a concise description of how key team members/staff proposed for this engagement, including a Client Manager, Project Manager, and other Key Team Members will execute the work and take ownership of maintaining proactive and strategic communication with the working group and Lake Worth Beach staff, as appropriate. Respondents shall summarize the ability of the firm to provide local expertise and Client Management and how distance barriers in terms of team members that are not local to FL will be overcome to ensure responsiveness.

Tab 6. Litigation and/or Terminations (unlimited pages)

Respondents shall provide a summary of any litigation filed against their firm or key personnel in the past five (5) years which is related to the services sought under this RFQ and that the Respondent provides in the regular course of business. The summary shall state the nature of the litigation, a brief description of the case, the outcome or projected outcome, and the monetary amount involved***. If none, state as such.***

Respondents shall also state if the Respondent has had a contract for the services sought under this RFQ which were terminated for default, non-performance or delay, in the past five (5) years. Respondents shall describe all such terminations, including the name and address of the other contracting party for each such occurrence. *If none, state as such.*

Tab 7 . Evidence of veteran business enterprise, small business and local business preference (unlimited pages)

Section 2-117 of the City's Procurement Code shall govern the application of a veteran business enterprise, small business and/or local business preference for this RFQ. **Documentation to support a Respondent as a Veteran Owned Business, Small Business and/or Local Business must be submitted with a Proposals in response to the RFQ.** Documentation submitted after the proposal deadline will be rejected.

Order and application of preferences. For all preferences set forth in this RFQ, only one preference may be identified in a response to this solicitation.

TAB 8. Forms & Licenses (unlimited pages)

Please include all necessary forms and licenses required.

14. REPRESENTATIONS BY SUBMITTAL OF QUALIFICATIONS

By submitting Qualifications, the Respondent warrants, represents and declares that:

A. Person(s) designated as principal(s) of the Respondent are named and that no other person(s) other than those therein mentioned has (have) any interest in the proposal or in the anticipated contract.

B. The Qualifications are submitted without connection, coordination or cooperation with any other persons, company, firm or party submitting Qualifications, and that the Qualifications are, in all respects, true and correct without collusion or fraud.

C. The Respondent understands and agrees to all elements of the RFQ unless otherwise indicated or negotiated, and that the RFQ shall become part of any contract entered into between the City and the Respondent.

D. By signing and submitting Qualifications, Respondent certifies that it and any parent corporations, affiliates, subsidiaries, members, shareholders, partners, officers, directors or executives thereof are not presently debarred, proposed for debarment or declared ineligible to bid or participate in any federal, state or local government agency projects.

E. Pursuant to 287.133, Florida Statutes, a person or affiliate who has been placed on the convicted firm list maintained by the State of Florida may not submit Qualifications to the City of Lake Worth Beach for 36 months following the date of being placed on the convicted firm list. Respondent certifies that submittal of its Qualifications does not violate this statute.

F. Respondent recognizes and agrees that the City will not be responsible or liable in any way for any losses that the Respondent may suffer from the disclosure or submittal of its Qualifications to third parties.

15. PROTESTS

Any actual Respondent who is aggrieved in connection with this RFQ may protest such procurement. The protest must be filed with the City in accordance with the City's procurement code. A complete copy of the City's procurement code is available on- line at municode.com under the City's code of ordinances (sections 2-111 – 2-117). The protest procedures are set forth at section 2-115. There are strict deadlines for filing a protest. Failure to abide by the deadlines will result in a waiver of the protest.

16. EXHIBITS

This RFQ consists of the following exhibits (which are incorporated herein by reference):

A. Exhibit A	Scope of Services and Background Information
B. Exhibit B	Respondent Information Form (must be submitted)
C. Exhibit C	Drug Free Workplace Form (must be submitted)
D. Exhibit D	References (must be submitted)
E. Exhibit E	Campaign Contribution Statement (must be submitted)
F. Exhibit F	Scrutinized Companies Certification (must be submitted)
G. Exhibit G	Veteran Business Enterprise, Small Business and/or Local Business Preference Form
H. Exhibit H	Federal Contract Clauses
I. Exhibit I	Additional Documentation and Historic Conceptual Plans

17. COMPLIANCE

All Qualifications received in accordance with this RFQ shall be subject to applicable Florida Statutes governing public records including without limitation Chapter 119, Florida Statutes. If any Respondent believes its Qualifications contain exempt or confidential information, the Respondent must identify the same at the time of submission of its Qualifications. Failure to do so may result in the waiver of such exemption or confidentiality.

END OF GENERAL INFORMATION

EXHIBIT A

REQUEST FOR QUALIFICATIONS RFQ # 24-XXX

SCOPE OF SERVICES

This Request for Qualifications Professional Services is governed by the Florida Statute 287.055.

"Professional services" means those services within the scope of the practice of architecture, professional engineering, landscape architecture, or registered surveying and mapping, as defined by the laws of the state, or those performed by any architect, professional engineer, landscape architect, or registered surveyor and mapper in connection with their professional employment or practice.

Location and Opportunity

The City of Lake Worth Beach is a coastal municipality of 7 square miles, located in Palm Beach County, Florida. The City's northern boundary is adjacent to the City of West Palm Beach's southern boundary and about 64 miles north of Miami. Downtown Lake Worth Beach is the artistic soul of Palm Beach County with a historic theater and a museum, live music clubs, coffee houses, art galleries, antique malls, retail stores, and many restaurants. The City's Municipal Beach Complex is located east of the Downtown area, adjacent to the Atlantic Ocean.

Property Description

The Municipal Beach Complex is a 19 ½ acres parcel owned by the City and generally located at 10 S. Ocean Blvd., Lake Worth Beach, Florida (Parcel Control Numbers: 38434426000010010 and 38434426000010070). The Complex includes the Casino Building, Pool Facility, waterfront park, parking area, picnic area, restrooms, municipal pier, and additional adjacent areas. The Casino Building includes a first-floor area currently leased to commercial tenants and a second floor area of approximately 5,000 SF of unfinished space, approximately 3,000 SF of finished event space and a catering kitchen. The Pool Facility encompasses 32,500 SF (including the pool building). The City built and opened the Pool Facility to the community in the early 1970's, which the City continued to operate until its most recent closure in 2016. The Municipal Beach Complex has 713 paid public parking spaces available that are operated and enforced by the City, including 50 spaces reserved for Lake Work Beach residents with a valid parking decal. The remaining spaces are digitally metered and have a maximum allowance of 8 hours.

History

Lake Worth Beach Casino 1920s

In 1919, a wooden drawbridge, the longest of its kind in the nation at the time, was constructed to provide additional access to the barrier land. That same year the Brelsford Family of Palm Beach deeded 1,000 ft of oceanfront land on the barrier island to the town. A wooden pavilion was constructed that served as a popular location for dining and dancing. Later the pavilion was replaced with the City's Casino and Baths. The Municipal Beach Complex was completed in 1922 opening to great fanfare and heralded as the Jewel of the Gold Coast. G. Sherman Childs was the architect for the Mediterranean Revival Styled facility, and it offered bathing in a saltwater pool, diving competitions, a second-floor ballroom, restaurants, boutiques and a variety of beach activities. The 1928 hurricane brought a redesign of the building with the winds removing the corner tower element and flagpole. They were replaced with a low dome and eagle. The building again suffered during the 1937 storm, which removed the new dome and the lower corner domes. Finally with the 1947 hurricane, much of the original structure was destroyed and the second floor had to be removed. A new building designed by Edgar S. Wortman in the more contemporary International Style was built to the south and the remains of the original were incorporated into the design and given a modern facelift. Though seriously deteriorated from years of storms and salt air, deferred maintenance, and multiple delays in various plans for its future, in 2010 the City embarked on a goal to rehabilitate/renovate the existing structure instead of building anew. Because of its location east of the coastal construction control line, the projected costs for an entirely new building, the site constraints imposed by the impending beach site improvements, and the community's attachment to the building, the decision was made to move forward with its rehabilitation and to again make it a Jewel of the Gold Coast.

2013 Renovated Municipal Beach Complex

In 2013, the City rehabilitated the Municipal Beach Complex, which officially re-opened to the public on March 1, 2013. The refurbished Complex quickly became the new beach destination in South Florida. The reconstructed Casino Building is true to its original 1920's architecture, and includes significant new additions to the west and south. While there is no gambling at the renovated Casino Building, the name "Casino" remains as a reminder of the history and importance of the building to the citizens of Lake Worth Beach.

The renovated Municipal Beach Complex features an oceanfront park, restrooms, and picnic facilities, which complement the William O. Lockhart Municipal Pier. Beach chairs, lounges and cabanas are available to rent at the beach.

The first floor of the Casino Building is currently leased out by various commercial tenants. The first floor includes multiple restaurants, an ice cream shop, and a t-shirt store.

A unique distinction on the second floor of the Casino Building is a 3,000 SF event space/ballroom that offers breathtaking views of the Atlantic Ocean with wrap-around terraces and provides a perfect location for weddings, special occasions, and other events. The ballroom has won Wedding Wire's Couples Choice Award four years in a row in 2017, 2018, 2019 and 2020 and was also featured in Married in Palm Beach in 2017, 2018 and 2019. Adjacent to the ballroom on the second floor is 5,000 SF of unfinished space and a nearby catering kitchen.

The Pool Facility was not included in the 2013 Municipal Beach Complex renovation project.

Below is an aerial photograph of the Municipal Beach Complex post-renovation.

Lake Worth Beach - Beach and Casino Land Development Regulations

All development at the Municipal Beach Complex must comply with the City's land use and zoning categories. The land use and zoning categories for the Municipal Beach Complex, including development regulations and allowable uses, are detailed below. This information may also be found in the City of Lake Worth Beach's Code of Ordinances.

The Municipal Beach Complex encompasses approximately 19 ½ acres and includes a 20,861 SF reconstructed Casino Ballroom building as well as 7,284 SF of various other structures. The site floor area ratio (FAR) is 0.033 based on the gross leasable area limit on the site of 64,715 SF. There is approximately 35,000 and 40,000 of allowed new construction that can be leased. For the overall site at the current FAR, the total allowable area allowed on the site is 127,413 SF. Consequently, there is roughly 100,000 SF of allowable building on the site of which up to 64,715 SF is leasable.

Maximum height per the City's Comprehensive Plan is 45' and two stories. By utilizing a planned development scenario of the site, the overall height can be raised to 65'-0' and three stories (the Transfer Development Rights (TDR) option would have to be triggered to gain the additional story).

Future Land Use Element

Policy 1.1.13: Beach and Casino - The Beach and Casino land use category designates the area of public beach and casino building area. The term "Casino" is used in name only and reflects the historic name of the buildings and site. Designation of this area signifies the expectation that the public beach will be used for public recreation and use and specified accessory uses, and the casino area will be used for a combination of permitted private commercial and public uses. The gross leasable area of all buildings shall not exceed 64,715 SF. The implementing zoning district is BAC.

Policy 1.2.15: Locational Criteria for the Beach and Casino Designation - The Beach and Casino land use designation is mapped on sites where such uses already exist. The mapping of these uses on these sites indicates that public beach will be used for public recreation use and specified accessory uses and casino area for a combination of permitted private commercial and public uses. Per Table I the Beach and Casino (BAC) Future Land Use Designation allows for a maximum height of 45' and a FAR of 0.15

Land Development Regulations

Sec. 23.3-22 BAC—Beach and Casino

a) Intent - The beach and casino district (BAC) is a zoning category for the Lake Worth public beach and casino area. It is intended for public use of the beach area and other beach related uses and private commercial and public uses in the casino area.

b) Principal uses permitted by right or by administrative or conditional use permit- Refer to the permitted use table at section 23.3-6 for complete list of uses.

1. In the beach area (east of the east edge of the existing seawall). Public beach and pier and accessory uses such as umbrella, beach chair, beach and water related rentals and cafes on the pier only, and special events permitted pursuant to section 21-18.

2. In the casino area (west of the east edge of the existing seawall):
    A. Pool, pool building and accessory uses.
    B. Picnic facilities, play-grounds, recreational uses and restrooms.
    C. Parking and parking structure.
    D. Ballroom, banquet and meeting rooms.
    E. Retail establishments. The sum of all retail establishments may not exceed seven thousand two hundred (7,200) SF.
    F. Restaurants (no drive thru), sandwich shops and snack bars, outdoor cafes and push carts.
    G. Special events as permitted pursuant to section 21-18.
    H. Environmental/nature centers, art shows, exhibits and other events not requiring a special event permit pursuant to section 21-18.

c) Development regulations

1. Building height:

A. Total building/structure height shall not exceed sixty (60) feet.
B. Two (2) habitable stories totaling not more than fifty (50) feet in height.
C. Architectural features not to exceed an additional ten (10) feet in height.
D. Building height shall be measured as defined in general definitions.
E. Parking structures shall not exceed three (3) levels or thirty-two (32) feet. The height of the highest parking surface shall not exceed the crown of the loop road closest to the seawall.

2. Setbacks:
A. East: Seventy-five (75) feet from the east edge of the existing seawall excluding public seating, outdoor patio and dining areas (which shall be at least forty-five (45) feet from the east edge of the existing seawall), public shelters, signage and push carts.
B. West: Seventy-five (75) feet from the property line.
C. North: Two hundred (200) feet from the property line excluding public seating, public shelters, signage, and picnic pavilions, (which shall be at least thirty-five (35) feet from the property line and which shall be subject to conditional use approval by the planning and zoning board).
D. South: Thirty-five (35) feet from the property line.

3. Building coverage: Fifteen (15) percent.

4. Maximum impermeable surface: Sixty-five (65) percent.

5. Floor area ratio. The maximum floor area ratio is 0.1.

d) Prohibited uses - All uses not specifically permitted.

Scope of Services

The intent of this solicitation is to acquire select professional services for the City of Lake Worth Beach to evaluate location feasibilities, perform required studies and develop potential options/scenarios for the facility and lead the City through the process of planning and implementation of the future development for the Casino complex and pool located at City of Lake Worth Beach.

The selected firm shall be responsible for all needed services which include but are not limited to the following:

- Engineering Services (structural, mechanical, electrical, plumbing, surveying and coastal)
- Coastal Zone Evaluation
- Schematic Design
- Design Development; design and construction phase services for capital improvements projects
- Civil Engineering
- Landscape and zoning studies and analysis
- Structural engineering
- MEP engineering

- Architectural services
- Geotechnical services
- Fire and Life Safety engineering
- Real estate feasibility and development studies
- Pool assessment
- Casino Building assessment
- Full review of site with definition of site limitations and opportunities
- Review of parking opportunities and options
- Options for Casino building and pool developments
- Potential for commercial development possibilities and P3
- Financial feasibility studies
- Estimates of potential revenue streams
- Development studies and opportunities
- Review and assessment of funding sources and grants
- Probable cost development for all projects and phases
- Development of operating costs for all options
- Compliance with applicable Codes and Regulations
- Appropriate recommendations to applicable Codes, Regulations and Comprehensive Plan to facilitate options/scenarios envisioned and provided
- Budget development and review
- Conceptual Design Documents
- Design Development Documents
- Construction Documents
- Permitting with applicable agencies
- Negotiating with sub-consultants, building contractors, and subcontractors
- Solicitation management with bid evaluations and recommendations
- Negotiations of contracts on behalf of the City
- Public involvement and community outreach
- Policy Development and Guidance
- Preparation of land development regulation and land use amendments, ordinances and resolutions as well as other necessary regulatory documents
- Community outreach and stakeholder meetings, workshops and charettes
- City Commission Presentations & Commission guidance
- Project Management/Programming
- Engineering Contract Administration
- Other services as develop through the process.

The City reserves the right, in its sole discretion, to award a contract for all or part of the services set forth above.

Subconsultants may be included to cover the broad scope of each category, but the selected firm will be required to assume responsibility for all services offered in their proposal. The selected firm will be the sole point of contact concerning all contractual matters.

Under this contract, the City will have the ability to expedite work through individual Task Orders based on specific scopes of work. Task Orders will be individually negotiated based on the "Fee Schedule" and any additional negotiated services required within the scope of work. The contract will be inclusive of a termination clause. Prior to the execution of the contract, the City will request an original certificate of insurance in keeping with Section 11 of this solicitation, a fee schedule, and other documentation as necessary, which will be appended as Exhibits to the Consulting Agreement. Prior to any work being ordered on a Task Order (which would be appended to a City Purchase Order), the fee, including hours per rate category, individuals performing the work, profit, direct expenses attributed to the project, etc., may be negotiated, after the specific scope of work has been defined.

NOTE: Fee schedules shall <u>not</u> be submitted with qualifications. They will be required during the negotiation phase which is after shortlisted announcement by the City.

EXHIBIT B

REQUEST FOR QUALIFICATIONS RFQ # 24-XXX

RESPONDENT INFORMATION PAGE

Company Name: _____

Authorized Signature: _____

Signature Print Name

Title: _____

Physical Address: _____

Street

_____

City State Zip Code

Telephone: _____ Fax: _____

Email Address: _____

Web Site (if applicable):_____

Federal Identification Number:_____

This is a requirement of every Respondent.

EXHIBIT C

REQUEST FOR QUALIFICATIONS RFQ # 24-XXX

CONFIRMATION OF DRUG-FREE WORKPLACE

In accordance with Section 287.087, Florida Statutes, whenever two or more Qualifications are equal with respect to price, quality, and service which are received by any political subdivision for the procurement of commodities or contractual services, a proposal received from a business that certifies that it has implemented a drug-free workplace program shall be given preference in the award process. In order to have a drug-free workplace program, a business shall:

(1) Publish a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the workplace and specifying the actions that will be taken against employees for violations of such prohibition.

(2) Inform employees about the dangers of drug abuse in the workplace, the business's policy of maintaining a drug-free workplace, any available drug counseling, rehabilitation, and employee assistance programs, and the penalties that may be imposed upon employees for drug abuse violations.

(3) Give each employee engaged in providing the commodities or contractual services that are under proposal a copy of the statement specified in subsection (1).

(4) In the statement specified in subsection (1), notify the employees that, as a condition of working on the commodities or contractual services that are under proposal, the employee will abide by the terms of the statement and will notify the employer of any conviction of, or plea of guilty or nolo contendere to, any violation of chapter 893 or of any controlled substance law of the United States or any state, for a violation occurring in the workplace no later than 5 days after such conviction.

(5) Impose a sanction on, or require the satisfactory participation in a drug abuse assistance or rehabilitation program if such is available in the employee's community by, any employee who is so convicted.

(6) Make a good faith effort to continue to maintain a drug-free workplace through implementation of this section.

As the person authorized to sign this statement on behalf of _____, I certify that _____ complies fully with the above requirements.

_____ _____
Authorized Representative's Signature Date

_____ _____
Name: Position:

EXHIBIT D

REQUEST FOR QUALIFICATIONS RFQ # 24-XXX

REFERENCES

List below or on an attached sheet similar past projects. Please provide the name, addresses and telephone numbers of organizations, governmental or private, for whom you now are, or have **within the past five (5) years** provided similar services. (THIS FORM MAY BE COPIED).

#**1 REFERENCE**

Name of Client: _____

Address: _____

Phone No.: (___)_____ Fax: (___)_____

Contact Person Name: _____ Title: _____

Description of services: _____

_____

_____

Project Location: _____.

Completed on time: Yes___ No ___ (explain:_____).

Completed within budget: Yes__ No__ (explain:_____).

#**2 REFERENCE**

Name of Client: _____

Address: _____

Phone No.: (___)_____ Fax: (___)_____

Contact Person Name: _____ Title: _____

Description of services: _____

_____

_____

Project Location: _____.

Completed on time: Yes___ No ___ (explain:_____).

Completed within budget: Yes__ No__ (explain:_____).

#3 REFERENCE

Name of Client: _____

Address: _____

Phone No.: (___)_____ Fax: (___)_____

Contact Person Name: _____ Title: _____

Description of services: _____

_____

_____

Project Location: _____.

Completed on time: Yes___ No ___ (explain:_____).

Completed within budget: Yes__ No__ (explain:_____).

EXHIBIT E

REQUEST FOR QUALIFICATIONS RFQ # 24-XXX

CAMPAIGN CONTRIBUTION STATEMENT

This RFQ is subject to Section 2-101of the City of Lake Worth Beach Code of Ordinances regarding campaign contributions which provides:

Sec. 2-101. - Additional and supplemental disclosures requirements.

(a) Any elected official of the City of Lake Worth, who is a current sitting member of the city commission and has accepted an election campaign contribution in an amount that is more than one hundred dollars ($100.00) from an individual or business entity having an interest in a matter before the city commission in which the city commission will take action, must publically disclose, both verbally and in writing, such contribution prior to any discussion or vote on the matter. The written disclosure must be submitted to the city clerk.

(b) Any applicant coming before the city commission for an award of a contract with the city and who has made an election campaign contribution in an amount that is more than one hundred dollars ($100.00) to any elected official of the city commission, who is a current sitting member of the commission, must disclose such election campaign contribution, verbally and in writing, during the application or bidding process and before the award of the contract.

Vendor to complete: Check which statement applies, fill in the requested information, if applicable, and sign below.

[ ] Neither the undersigned business nor any of its owners or officers contributed more than $100.00 to the campaign of a sitting City Commission member. [If you checked this statement, you are done and may sign below.]

[ ] The undersigned business or one or more of its owners or officers contributed more than $100.00 to the campaign of a sitting City Commission member. All such contributions are listed below and on the attached sheet of paper (if more room is needed). [If you checked this statement, please fill in the information requested below and sign below.]

1. _____ contributed a total of $_____ to the campaign of City Commission member _____.
2. _____ contributed a total of $_____ to the campaign of City Commission member _____.
3. _____ contributed a total of $_____ to the campaign of City Commission member _____.
4. _____ contributed a total of $_____ to the campaign of City Commission member _____.

Signature:
I hereby certify that the above statements are true and correct to the best of my knowledge and I understand that a false or inaccurate statement may result in the rejection of this bid/proposal/submittal or the immediate termination of any resulting agreement with the City of Lake Worth.

By: _____

Print Name: _____

Print Title: _____

Print Name of Business: _____

Commissioner/Mayor to complete: Check which statement applies, fill in the requested information, if applicable, and sign below.

[ ] Neither the above referenced business nor any of its owners or officers contributed more than $100.00 to my campaign. [If you checked this statement, you are done and may sign below.]

[ ] The above referenced business or one or more of its owners or officers contributed more than $100.00 to my campaign. All such contributions are listed below and on the attached sheet of paper (if more room is needed). [If you checked this statement, please fill in the information requested below and sign below.]

_____ contributed a total of $_____ to my campaign.

_____ contributed a total of $_____ to my campaign.

_____ contributed a total of $_____ to my campaign.

_____ contributed a total of $_____ to my campaign.

Signature:
I hereby certify that the above statements are true and correct to the best of my knowledge and I understand that a false or inaccurate statement may result in the rejection of this bid/proposal/submittal or the immediate termination of any resulting agreement with the City of Lake Worth.

By: _____

Print Name: _____

For City Clerk's Use Only.

THIS SECTION SHALL BE COMPLETED ONLY IF THERE IS A CAMPAIGN CONTRIBUTION LISTED ABOVE BY THE VENDOR OR COMMISSION MEMBER.

Applicable campaign contributions were disclosed in writing above, and prior to the award of the contract, the following statements were verbally made at the City Commission Meeting on the ____ day of _____, 201___.

Check all that apply.

_____ Commissioner/Mayor _____ verbally disclosed the campaign contribution(s) set forth above.

_____ Vendor, _____, verbally disclosed the campaign contribution(s) set forth above.

EXHIBIT F

REQUEST FOR QUALIFICATIONS RFQ # 24-XXX

SCRUTINIZED COMPANIES CERTIFICATION FORM

By execution below, I, _____, on behalf of _____ (hereinafter, the "Contractor"), hereby swear or affirm to the following certifications:

The following certifications apply to all procurements:

1. The Consultant has reviewed section 215.4725, Florida Statutes, section 215.473, Florida Statutes and section 287.135, Florida Statutes, and understands the same.
2. The Consultant is not on the Scrutinized Companies that Boycott Israel List nor is the Consultant engaged in a boycott of Israel.
3. If awarded a contract, the Consultant agrees to require these certifications for applicable subcontracts entered into for the performance of work/services under this procurement.
4. If awarded a contract, the Consultant agrees that the certifications in this section shall be effective and relied upon by the City for the entire term of the contract, including any and all renewals.

If the contract awarded hereunder is for one million dollars or more, the following additional certifications apply:

1. The Consultant is not on the Scrutinized Companies with Activities in Sudan List.
2. The Consultant is not on the Scrutinized Companies with Activities in the Iran Petroleum Energy Sector List.
3. The Consultant is not engaged in business operations in Cuba or Syria.
5. If awarded a contract, the Consultant agrees to require these certifications for applicable subcontracts entered into for the performance of work/services under this procurement.
6. If awarded a contract, the Consultant agrees that the certifications in this section shall be effective and relied upon by the City for the entire term of the contract, including any and all renewals.

EXHIBIT G

REQUEST FOR QUALIFICATIONS RFQ # 24-XXX

Veteran Business Enterprise, Small Business and/or Local Business Preference Form

Section 2-117 of the City's Code of Ordinances shall govern the application of a Veteran Business Enterprise, Small Business and/or Local Business preference for this RFQ.

The undersigned Respondent, hereby claims the following preference:

- ☐ Veteran Business Enterprise
- ☐ Small Business
- ☐ Local Business

Documentation to support a Respondent as a Veteran Business Enterprise, Small Business and/or Local Business must be submitted with a bid in response to the RFQ and attached to this form. Documentation submitted after the RFQ deadline will be rejected.

Signature:

I hereby certify that the above statements are true and correct to the best of my knowledge and I understand that a false or inaccurate statement may result in the rejection of this bid/proposal/submittal or the immediate termination of any resulting agreement with the City of Lake Worth Beach.

By: _____

Print Name: _____

Print Title: _____

Print Name of Business: _____

EXHIBIT "H"
REQUEST FOR QUALIFICATIONS RFQ # 24-XXX

Federal Contract Provisions

The Consultant hereby agrees that the following terms, at a minimum, will be incorporated into any subsequent contract resulting from this RFQ:

Equal Employment Opportunity. During the performance of the resulting contract, the Contractor agrees as follows:

(1) The Consultant will not discriminate against any employee or applicant for employment because of race, color, religion, sex, sexual orientation, gender identity, or national origin. The Consultant will take affirmative action to ensure that applicants are employed, and that employees are treated during employment without regard to their race, color, religion, sex, sexual orientation, gender identity, or national origin. Such action shall include, but not be limited to the following: Employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Consultant agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided setting forth the provisions of this nondiscrimination clause.

(2) The Consultant will, in all solicitations or advertisements for employees placed by or on behalf of the contractor, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, or national origin.

(3) The Consultant will not discharge or in any other manner discriminate against any employee or applicant for employment because such employee or applicant has inquired about, discussed, or disclosed the compensation of the employee or applicant or another employee or applicant. This provision shall not apply to instances in which an employee who has access to the compensation information of other employees or applicants as a part of such employee's essential job functions discloses the compensation of such other employees or applicants to individuals who do not otherwise have access to such information, unless such disclosure is in response to a formal complaint or charge, in furtherance of an investigation, proceeding, hearing, or action, including an investigation conducted by the employer, or is consistent with the contractor's legal duty to furnish information.

(4) The Consultant will send to each labor union or representative of workers with which he has a collective bargaining agreement or other contract or understanding, a notice to be provided advising the said labor union or workers' representatives of the contractor's commitments under this section, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

(5) The Consultant will comply with all provisions of Executive Order 11246 of September 24, 1965, and of the rules, regulations, and relevant orders of the Secretary of Labor.

(6) The Consultant will furnish all information and reports required by Executive Order 11246 of September 24, 1965, and by rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to his books, records, and accounts by the administering agency and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(7) In the event of the contractor's noncompliance with the nondiscrimination clauses of this contract or with any of the said rules, regulations, or orders, this contract may be canceled, terminated, or suspended in whole or in part and the Consultant may be declared ineligible for further Government contracts or federally assisted construction contracts in accordance with procedures authorized in Executive Order 11246 of September 24, 1965, and such other sanctions may be imposed and remedies invoked as provided in Executive Order 11246 of

September 24, 1965, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

(8) The Consultant will include the portion of the sentence immediately preceding paragraph (1) and the provisions of paragraphs (1) through (8) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to section 204 of Executive Order 11246 of September 24, 1965, so that such provisions will be binding upon each subcontractor or vendor. The Consultant will take such action with respect to any subcontract or purchase order as the administering agency may direct as a means of enforcing such provisions, including sanctions for noncompliance: Provided, however, that in the event a Consultant becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction by the administering agency, the Consultant may request the United States to enter into such litigation to protect the interests of the United States.

The applicant further agrees that it will be bound by the above equal opportunity clause with respect to its own employment practices when it participates in federally assisted construction work: Provided, That if the applicant so participating is a State or local government, the above equal opportunity clause is not applicable to any agency, instrumentality or subdivision of such government which does not participate in work on or under the contract. The applicant agrees that it will assist and cooperate actively with the administering agency and the Secretary of Labor in obtaining the compliance of contractors and subcontractors with the equal opportunity clause and the rules, regulations, and relevant orders of the Secretary of Labor, that it will furnish the administering agency and the Secretary of Labor such information as they may require for the supervision of such compliance, and that it will otherwise assist the administering agency in the discharge of the agency's primary responsibility for securing compliance.

The applicant further agrees that it will refrain from entering into any contract or contract modification subject to Executive Order 11246 of September 24, 1965, with a Consultant debarred from, or who has not demonstrated eligibility for, Government contracts and federally assisted construction contracts pursuant to the Executive Order and will carry out such sanctions and penalties for violation of the equal opportunity clause as may be imposed upon contractors and subcontractors by the administering agency or the Secretary of Labor pursuant to Part II, Subpart D of the Executive Order. In addition, the applicant agrees that if it fails or refuses to comply with these undertakings, the administering agency may take any or all of the following actions: Cancel, terminate, or suspend in whole or in part this grant (contract, loan, insurance, guarantee); refrain from extending any further assistance to the applicant under the program with respect to which the failure or refund occurred until satisfactory assurance of future compliance has been received from such applicant; and refer the case to the Department of Justice for appropriate legal proceedings.

Compliance with the Contract Work Hours and Safety Standards Act.

(1) Overtime requirements. No Consultant or subcontractor contracting for any part of the contract work which may require or involve the employment of laborers or mechanics shall require or permit any such laborer or mechanic in any workweek in which he or she is employed on such work to work in excess of forty hours in such workweek unless such laborer or mechanic receives compensation at a rate not less than one and one-half times the basic rate of pay for all hours worked in excess of forty hours in such workweek.

(2) Violation; liability for unpaid wages; liquidated damages. In the event of any violation of the clause set forth in paragraph (1) of this section the Consultant and any subcontractor responsible therefor shall be liable for the unpaid wages. In addition, such Consultant and subcontractor shall be liable to the United States (in the case of work done under contract for the District of Columbia or a territory, to such District or to such territory), for liquidated damages. Such liquidated damages shall be computed with respect to each individual laborer or mechanic, including watchmen and guards, employed in violation of the clause set forth in paragraph (1) of

this section, in the sum of $27 for each calendar day on which such individual was required or permitted to work in excess of the standard workweek of forty hours without payment of the overtime wages required by the clause set forth in paragraph (1) of this section.
(3) Withholding for unpaid wages and liquidated damages. DOJ, the State of Florida, or the CITY shall upon its own action or upon written request of an authorized representative of the Department of Labor withhold or cause to be withheld, from any moneys payable on account of work performed by the Consultant or subcontractor under any such contract or any other Federal contract with the same prime contractor, or any other federally-assisted contract subject to the Contract Work Hours and Safety Standards Act, which is held by the same prime contractor, such sums as may be determined to be necessary to satisfy any liabilities of such Consultant or subcontractor for unpaid wages and liquidated damages as provided in the clause set forth in paragraph (2) of this section.
(4) Subcontracts. The Consultant or subcontractor shall insert in any subcontracts the clauses set forth in paragraph (1) through (4) of this section and also a clause requiring the subcontractors to include these clauses in any lower tier subcontracts. The prime Consultant shall be responsible for compliance by any subcontractor or lower tier subcontractor with the clauses set forth in paragraphs (1) through (4) of this section.

Rights to Inventions Made Under a Contract or Agreement
If the Federal award meets the definition of "funding agreement" under 37 CFR § 401.2(a) and the recipient or subrecipient wishes to enter into a contract with a small business firm or nonprofit organization regarding the substitution of parties, assignment or performance of experimental, developmental, or research work under that "funding agreement," the recipient or subrecipient must comply with the requirements of 37 CFR Part 401, "Rights to Inventions Made by Nonprofit Organizations and Small Business Firms Under Government Grants, Contracts and Cooperative Agreements," and any implementing regulations issued by the awarding agency.

Clean Air Act
(1) The Consultant agrees to comply with all applicable standards, orders or regulations issued pursuant to the Clean Air Act, as amended, 42 U.S.C. § 7401 et seq.
(2) The Consultant agrees to report each violation to the City, and understands and agrees that the City will, in turn, report each violation as required to assure notification to the Federal Emergency Management Agency, and the appropriate Environmental Protection Agency Regional Office.
(3) The Consultant agrees to include these requirements in each subcontract exceeding $150,000 financed in whole or in part with Federal assistance provided by DOJ.

Federal Water Pollution Control Act
(1) The Consultant agrees to comply with all applicable standards, orders, or regulations issued pursuant to the Federal Water Pollution Control Act, as amended, 33 U.S.C. 1251 et seq.
(2) The Consultant agrees to report each violation to the CITY and understands and agrees that the CITY will, in turn, report each violation as required to assure notification to the Federal Emergency Management Agency, and the appropriate Environmental Protection Agency Regional Office.
(3) The Consultant agrees to include these requirements in each subcontract exceeding $150,000 financed in whole or in part with Federal assistance provided by DOJ.

Suspension and Debarment.
(1) This contract is a covered transaction for purposes of 2 C.F.R. pt. 180 and 2 C.F.R. pt. 3000. As such, the Consultant is required to verify that none of the contractor's principals (defined at 2 C.F.R. § 180.995) or its affiliates (defined at 2 C.F.R. § 180.905) are excluded (defined at 2 C.F.R. § 180.940) or disqualified (defined at 2 C.F.R. § 180.935).

(2) The Consultant must comply with 2 C.F.R. pt. 180, subpart C and 2 C.F.R. pt. 3000, subpart C, and must include a requirement to comply with these regulations in any lower tier covered transaction it enters into.
(3) This certification, as laid out in Exhibit I, is a material representation of fact relied upon by the City. If it is later determined that the Consultant did not comply with 2 C.F.R. pt. 180, subpart C and 2 C.F.R. pt. 3000, subpart C, in addition to remedies available to the State of Florida or the City, the Federal Government may pursue available remedies, including but not limited to suspension and/or debarment.
(4) The bidder or proposer agrees to comply with the requirements of 2 C.F.R. pt. 180, subpart C and 2 C.F.R. pt. 3000, subpart C while this offer is valid and throughout the period of any contract that may arise from this offer. The bidder or proposer further agrees to include a provision requiring such compliance in its lower tier covered transactions.

Byrd Anti-Lobbying Amendment.
Contractors who apply or bid for an award of $100,000 or more shall file the required certification as laid out in Exhibit J. Each tier certifies to the tier above that it will not and has not used Federal appropriated funds to pay any person or organization for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, officer or employee of Congress, or an employee of a Member of Congress in connection with obtaining any Federal contract, grant, or any other award covered by 31 U.S.C. § 1352. Each tier shall also disclose any lobbying with non-Federal funds that takes place in connection with obtaining any Federal award. Such disclosures are forwarded from tier to tier up to the recipient who in turn will forward the certification(s) to the awarding agency.

Procurement of Recovered materials.
(i) In the performance of this contract, the Consultant shall make maximum use of products containing recovered materials that are EPA-designated items unless the product cannot be acquired—
- Competitively within a timeframe providing for compliance with the contract performance schedule;
- Meeting contract performance requirements; or
- At a reasonable price.

(ii) Information about this requirement, along with the list of EPA-designated items, is available at EPA's Comprehensive Procurement Guidelines web site, https://www.epa.gov/smm/comprehensive- procurement-guideline-cpg-program.
(iii) The Consultant also agrees to comply with all other applicable requirements of Section 6002 of the Solid Waste Disposal Act."

Access to Records.
(1) The Consultant agrees to provide the State of Florida, the CITY, the DOJ Administrator, the Comptroller General of the United States, or any of their authorized representatives access to any books, documents, papers, and records of the Consultant which are directly pertinent to this contract for the purposes of making audits, examinations, excerpts, and transcriptions.
(2) The Consultant agrees to permit any of the foregoing parties to reproduce by any means whatsoever or to copy excerpts and transcriptions as reasonably needed.
(3) The Consultant agrees to provide the DOJ Administrator or his authorized representatives access to construction or other work sites pertaining to the work being completed under the contract.
(4) In compliance with the Disaster Recovery Act of 2018, the City and the Consultant acknowledge and agree that no language in this contract is intended to prohibit audits or internal reviews by the DOJ Administrator or the Comptroller General of the United States.

DHS Seal, Logo, and Flags. The Consultant shall not use the DHS seal(s), logos, crests, or reproductions of flags or likenesses of DHS agency officials without specific DOJ pre-approval.

Compliance with Federal Law, Regulations, and Executive Orders. By signing this agreement, the Consultant acknowledges that DOJ financial assistance will be used to fund all or a portion of the contract. The Consultant will comply with all applicable Federal law, regulations, executive orders, DOJ policies, procedures, and directives.

No Obligation by Federal Government. The Federal Government is not a party to this contract and is not subject to any obligations or liabilities to the non-Federal entity, contractor, or any other party pertaining to any matter resulting from the contract.

Program Fraud and False or Fraudulent Statements or Related Acts. The Consultant acknowledges that 31 U.S.C. Chap. 38 (Administrative Remedies for False Claims and Statements) applies to the Contractor's actions pertaining to this contract.

Affirmative Steps. Required Affirmative Steps
If the Consultant intends to subcontract any portion of the work covered by this Contract, the Consultant must take all necessary affirmative steps to assure that small and minority businesses, women's business enterprises and labor surplus area firms are solicited and used when possible. Affirmative steps must include:
(1) Placing qualified small and minority businesses and women's business enterprises on solicitation lists;
(2) Assuring that small and minority businesses, and women's business enterprises are solicited whenever they are potential sources;
(3) Dividing total requirements, when economically feasible, into smaller tasks or quantities to permit maximum participation by small and minority businesses, and women's business enterprises;
(4) Establishing delivery schedules, where the requirement permits, which encourage participation by small and minority businesses, and women's business enterprises; and
(5) Using the services and assistance, as appropriate, of such organizations as the Small Business Administration and the Minority Business Development Agency of the Department of Commerce.
Domestic preferences for procurements.
(1) As appropriate and to the extent consistent with law, the Consultant should purchase, acquire, or use of goods, products, or materials produced in the United States (including but not limited to iron, aluminum, steel, cement, and other manufactured products).
(2) For purposes of this section:
(a) "Produced in the United States" means, for iron and steel products, that all manufacturing processes, from the initial melting stage through the application of coatings, occurred in the United States.
(b) "Manufactured products" means items and construction materials composed in whole or in part of non-ferrous metals such as aluminum; plastics and polymer-based products such as polyvinyl chloride pipe; aggregates such as concrete; glass, including optical fiber; and lumber.
Prohibition on certain telecommunications and video surveillance services or equipment.
(1) The Consultant is prohibited from obligating or expending loan or grant funds to:
(a) Procure or obtain;
(b) Extend or renew a contract to procure or obtain; or
(c) Enter into a contract (or extend or renew a contract) to procure or obtain equipment, services, or systems that uses covered telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system. As described in Public Law 115-232, section 889, covered telecommunications equipment is

telecommunications equipment produced by Huawei Technologies Company or ZTE Corporation (or any subsidiary or affiliate of such entities).
(i) For the purpose of public safety, security of government facilities, physical security surveillance of critical infrastructure, and other national security purposes, video surveillance and telecommunications equipment produced by Hytera Communications Corporation, Hangzhou Hikvision Digital Technology Company, or Dahua Technology Company (or any subsidiary or affiliate of such entities).
(ii) Telecommunications or video surveillance services provided by such entities or using such equipment.
(iii) Telecommunications or video surveillance equipment or services produced or provided by an entity that the Secretary of Defense, in consultation with the Director of the National Intelligence or the Director of the Federal Bureau of Investigation, reasonably believes to be an entity owned or controlled by, or otherwise connected to, the government of a covered foreign country.
(2) In implementing the prohibition under Public Law 115-232, section 889, subsection (f), paragraph (1), the City shall prioritize available funding and technical support to assist affected businesses, institutions and organizations as is reasonably necessary for those affected entities to transition from covered communications equipment and services, to procure replacement equipment and services, and to ensure that communications service to users and customers is sustained.

EXHIBIT "I"

Additional Documentation and Historic Conceptual Plans

EXISTING POOL FOOTPRINT

SHADE STRUCTURE

SUNSET VIEWING

SERVICE ACCESS BELOW

CHANGING ROOMS + RESTROOMS

LIFEGUARD OFFICE

PUBLIC RESTROOMS

FOOD PAVILION

ENTRY

ADMINISTRATION

10 S OCEAN BOULEVARD

3'-0"

4'-0"

6'-0"

10'-0"

LEGEND:

1. SPLASH PAD
2. LANDSCAPE
3. POOL STEPS
4. FOOD PAVILION
5. DUNE PLANTING
6. COVERED SEATING
7. FOOD TRUCK AREA

N

GRAPHIC SCALE
0 20 40
SCALE= 1" = 20'

NOTE: PRINTED DRAWING SIZE MAY HAVE CHANGED FROM ORIGINAL. VERIFY SCALE USING BAR SCALE ABOVE.

KEITH
301 East Atlantic Blvd.
Pompano Beach, FL 33060
PH: (954) 788-3400

Florida Engineering Business License: CA7928
Florida Surveyor and Mapper Business License: LB6860
Florida Landscape Architecture Business License: LC26000457

REVISIONS

NO.	DESCRIPTION	DATE

PRELIMINARY PLAN NOT FOR CONSTRUCTION

THESE PLANS ARE NOT FULLY PERMITTED AND ARE SUBJECT TO REVISIONS MADE DURING THE PERMITTING PROCESS.

RESPONSIBILITY FOR THE USE OF THESE PLANS PRIOR TO OBTAINING PERMITS FROM ALL AGENCIES HAVING JURISDICTION OVER THE PROJECT WILL FALL SOLELY UPON THE USER.

ISSUE DATE:
DESIGNED BY:
DRAWN BY:
CHECKED BY:
BID-CONTRACT:

CPZ 20 YEARS
4316 WEST BROWARD BOULEVARD
PLANTATION, FL 33317
PH: 954.792.8525 EXT 102

CLIENT

CITY OF LAKE WORTH

PROJECT

LAKE WORTH BEACH COMPLEX

SHEET TITLE

2023 - 04 - 03

ILLUSTRATIVE PLAN
CONCEPT C
OPTION 4

SHEET NUMBER LC-101

PROJECT NUMBER 10036.00

STATUS: PRELIMINARY

Plotted by: gmartin On 10/5/2022 12:07 PM

Drawing name: Q:\10036.00 - 1741 Lake Worth Beach Complex RFQ 17-305 - CPZ Architects\Landscape Architecture\CAD\10936.00-LC-1XX.dwg

LEGEND:

1. SPLASH PAD
2. ARTIFICIAL TURF
3. POOL STEPS
4. TIKI AREA
5. DUNE PLANTING
6. COVERED SEATING
7. FOOD TRUCK AREA

CONCEPT B OPTION 1	
	AMOUNT
	$ -
	903,142
	733,442
	42,881
	28,588
	28,588
	142,938
	415,638
	142,938
	45,900
	0
	0
	1,718,854
	0
	25,729
	88,621
	145,796
	248,319
	0
	0
	756,996
	548,100
	207,920
	$ 6,224,388
	$ 746,927
	$ 6,971,315
	$ 278,853
	$ 7,250,167
	$ 435,010
	$ 7,685,177
	$ 99,139
	$ 7,784,316
	$ 1,167,647
	8,951,963
	$ 1,790,393
	$ 10,742,356

EXISTING POOL FOOTPRINT

SHADE STRUCTURE

SUNSET VIEWING

SERVICE ACCESS BELOW

CHANGING ROOMS + RESTROOMS

3'-0"

4'-0"

6'-0"

10'-0"

LIFEGUARD OFFICE

PUBLIC RESTROOMS

TACO BAR

ENTRY

ADMINISTRATION

10 S OCEAN BOULEVARD

LEGEND:

1. SPLASH PAD
2. ARTIFICIAL TURF
3. POOL STEPS
4. TIKI AREA
5. DUNE PLANTING
6. COVERED SEATING
7. FOOD TRUCK AREA

N

GRAPHIC SCALE

0 20 40

SCALE= 1" = 20'

NOTE: PRINTED DRAWING SIZE MAY HAVE CHANGED FROM ORIGINAL. VERIFY SCALE USING BAR SCALE ABOVE.

CONCEPT B OPTION 2	AMOUNT
	$ -
	903,142
	733,442
	42,881
	28,588
	28,588
	142,938
	415,638
	142,938
	45,900
	0
	0
	2,123,078
	0
	25,729
	88,621
	145,796
	248,319
	0
	0
	756,996
	548,100
	207,920
	$ 6,628,612
	$ 795,433
	$ 7,424,045
	$ 296,962
	$ 7,721,007
	$ 463,260
	$ 8,184,267
	$ 105,577
	$ 8,289,845
	$ 1,243,477
	9,533,321
	$ 1,906,664
	$ 11,439,985

STATUS: PRELIMINARY

Plotted by: gmartin On 10/5/2022 12:07 PM
Drawing name: Q:\10936.00 - 1741 Lake Worth Beach Complex RFQ 17-305 - CPZ Architects\Landscape Architecture\CAD\10936.00-LC-1X5.dwg

LEGEND:

1. SPLASH PAD
2. ARTIFICIAL TURF
3. POOL STEPS
4. TIKI AREA
5. DUNE PLANTING
6. COVERED SEATING
7. FOOD TRUCK AREA

CONCEPT B OPTION 3	
AMOUNT	
$ -	
903,142	
733,442	
42,881	
28,588	
28,588	
142,938	
415,638	
142,938	
45,900	
0	
0	
2,348,933	
0	
25,729	
88,621	
145,796	
248,319	
0	
0	
756,996	
548,100	
207,920	
$ 6,854,467	
$ 822,536	
$ 7,677,003	
$ 307,080	
$ 7,984,083	
$ 479,045	
$ 8,463,128	
$ 109,174	
$ 8,572,302	
$ 1,285,845	
9,858,148	
$ 1,971,630	
$ 11,829,777	

CMS-CONSTRUCTION MANAGEMENT SERVICES, INC.
1115 HERON BAY BLVD, SUITE 204
CORAL SPRINGS, FL 33076
(954) 481-1611
CMS FILE # 2333 ORDER OF MAGNITUDE

CITY OF LAKE WORTH
LAKE WORTH BEACH COMPLEX
10 S OCEAN BLVD
LAKE WORTH, FLORIDA 33460

CPZ DRAWINGS - OPTIONS 1, 2 & 3
ORDER OF MAGNITUDE OPTIONS 1, 2 & 3
December 21, 2022

PREPARED FOR:
CPZ ARCHITECTS

SCHEDULE OF VALUES CONCEPT B

DIVISION	DESCRIPTION	CONCEPT B - BASE	CONCEPT B OPTION 1	CONCEPT B OPTION 2	CONCEPT B OPTION 3	CONCEPT B - LIFEGUARD OFFICES	CONCEPT B - PUBLIC RESTROOMS	CONCEPT B TACO BAR	CONCEPT B ADMIN PORTION OF TACO BAR	CONCEPT B SPLASH PAD	CONCEPT B EXTERIOR PAVING IMPROVEMENTS
		AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT
01000	GENERAL CONDITIONS - SEE BREAKOUT BELOW	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
02000	SITE WORK / DEMOLITION	903,142	903,142	903,142	903,142	0	0	0	0	$ -	$ -
03000	CONCRETE	733,442	733,442	733,442	733,442	208,594	94,875	88,125	52,031	$ 95,438	$ -
04000	MASONRY	42,881	42,881	42,881	42,881	20,859	9,488	8,813	5,203	$ -	$ -
05000	METALS	28,588	28,588	28,588	28,588	13,906	6,325	5,875	3,469	$ -	$ -
06000	WOOD AND PLASTICS	28,588	28,588	28,588	28,588	6,953	3,163	2,938	1,734	$ -	$ -
07000	THERMAL / MOISTURE PROTECTION	142,938	142,938	142,938	142,938	41,719	18,975	17,625	10,406	$ -	$ -
08000	DOORS AND WINDOWS	415,638	415,638	415,638	415,638	41,719	18,975	17,625	10,406	$ -	$ -
09000	FINISHES	142,938	142,938	142,938	142,938	69,531	31,625	29,375	17,344	$ -	$ -
10000	SPECIALTIES / SIGNAGE	45,900	45,900	45,900	45,900	0	0	0	0	$ -	$ -
11000	EQUIPMENT	0	0	0	0	41,719	0	0	0	$ -	$ -
12000	FURNISHINGS	0	0	0	0	0	0	0	0	$ -	$ -
13000	SPECIAL CONSTRUCTION	1,255,568	1,718,854	2,123,078	2,348,933	0	0	0	0	$ -	$ -
14000	CONVEYING SYSTEMS	0	0	0	0	0	0	0	0	$ -	$ -
21000	FIRE	25,729	25,729	25,729	25,729	12,516	5,693	5,288	3,122	$ -	$ -
22000	PLUMBING	88,621	88,621	88,621	88,621	43,109	40,480	18,213	10,753	$ 69,988	$ -
23000	HVAC	145,796	145,796	145,796	145,796	70,922	32,258	29,963	17,691	$ -	$ -
26000	ELECTRICAL	248,319	248,319	248,319	248,319	89,000	41,113	38,188	22,547	$ 159,063	$ -
27000	TECHNOLOGY	0	0	0	0	0	0	0	0	$ -	$ -
28000	ELECTRONIC SAFETY & SECURITY	0	0	0	0	0	0	0	0	$ -	$ -
31000	SITE WORK, EARTHWORK, ASPHALT PAVING, SIDE WALKS	756,996	756,996	756,996	756,996	0	0	0	0	$ 445,375	$ -
32000	EXTERIOR IMPROVEMENTS	548,100	548,100	548,100	548,100	0	0	0	0	$ 95,438	$ 62,500
33000	SITE UTILITIES	207,920	207,920	207,920	207,920	0	0	0	0	$ -	$ -
	SUBTOTALS: DIRECT/HARD COSTS	**$ 5,761,102**	**$ 6,224,388**	**$ 6,628,612**	**$ 6,854,467**	**$ 660,547**	**$ 302,968**	**$ 262,025**	**$ 154,706**	**$ 865,300**	**$ 62,500**
12.00%	GENERAL CONDITIONS	$ 691,332	$ 746,927	$ 795,433	$ 822,536	$ 79,266	$ 36,356	$ 31,443	$ 18,565	$ 103,836	$ 7,500
	SUBTOTAL	**$ 6,452,434**	**$ 6,971,315**	**$ 7,424,045**	**$ 7,677,003**	**$ 739,813**	**$ 339,324**	**$ 293,468**	**$ 173,271**	**$ 969,136**	**$ 70,000**
4.00%	G.C. OVERHEAD	$ 258,097	$ 278,853	$ 296,962	$ 307,080	$ 29,593	$ 13,573	$ 11,739	$ 6,931	$ 38,765	$ 2,800
	SUBTOTAL	**$ 6,710,531**	**$ 7,250,167**	**$ 7,721,007**	**$ 7,984,083**	**$ 769,405**	**$ 352,897**	**$ 305,207**	**$ 180,202**	**$ 1,007,901**	**$ 72,800**
6.00%	G.C PROFIT	$ 402,632	$ 435,010	$ 463,260	$ 479,045	$ 46,164	$ 21,174	$ 18,312	$ 10,812	$ 60,474	$ 4,368
	SUBTOTAL	**$ 7,113,163**	**$ 7,685,177**	**$ 8,184,267**	**$ 8,463,128**	**$ 815,569**	**$ 374,070**	**$ 323,519**	**$ 191,014**	**$ 1,068,376**	**$ 77,168**
1.29%	G.C. P&P BOND	$ 91,760	$ 99,139	$ 105,577	$ 109,174	$ 10,521	$ 4,826	$ 4,173	$ 2,464	$ 13,782	$ 995
	SUBTOTAL	**$ 7,204,923**	**$ 7,784,316**	**$ 8,289,845**	**$ 8,572,302**	**$ 826,090**	**$ 378,896**	**$ 327,693**	**$ 193,478**	**$ 1,082,158**	**$ 78,163**
15.00%	ESCALATION (ALLOWANCE)	$ 1,080,738	$ 1,167,647	$ 1,243,477	$ 1,285,845	$ 123,914	$ 56,834	$ 49,154	$ 29,022	$ 162,324	$ 11,725
	SUBTOTAL	**8,285,662**	**8,951,963**	**9,533,321**	**9,858,148**	**950,004**	**435,730**	**376,846**	**222,500**	**$ 1,244,481**	**$ 89,888**
20.00%	CONTINGENCY	$ 1,657,132	$ 1,790,393	$ 1,906,664	$ 1,971,630	$ 190,001	$ 87,146	$ 75,369	$ 44,500	$ 248,896	$ 17,978
	TOTAL PROBABLE CONSTRUCTION COST	**$ 9,942,794**	**$ 10,742,356**	**$ 11,439,985**	**$ 11,829,777**	**$ 1,140,004**	**$ 522,876**	**452,216**	**267,000**	**$ 1,493,377**	**$ 107,866**

LAKE WORTH BEACH COMPLEX | THE ART OF FLORIDA LIVING

NEW POOL COMPLEX CONCEPTUAL PACKAGE

August 14, 2019

EXISTING AERIAL VIEW
LAKE WORTH CASINO
BUILDING COMPLEX

NEW POOL COMPLEX
BOUNDARY

Original Schematic Design Concept
Meetings with Commissioners

2 **Conceptual Schemes**

SCHEME A

Scheme A

CPZ Architects | KEITH | Aquatic Consulting Engineers

Scheme A

Glass Wall

Open Plaza
Tiki Bar

Pool Entry

Staff and Meeting Room

Restroom

Future Stair and Drop Off

Public Restroom

Splash Pad

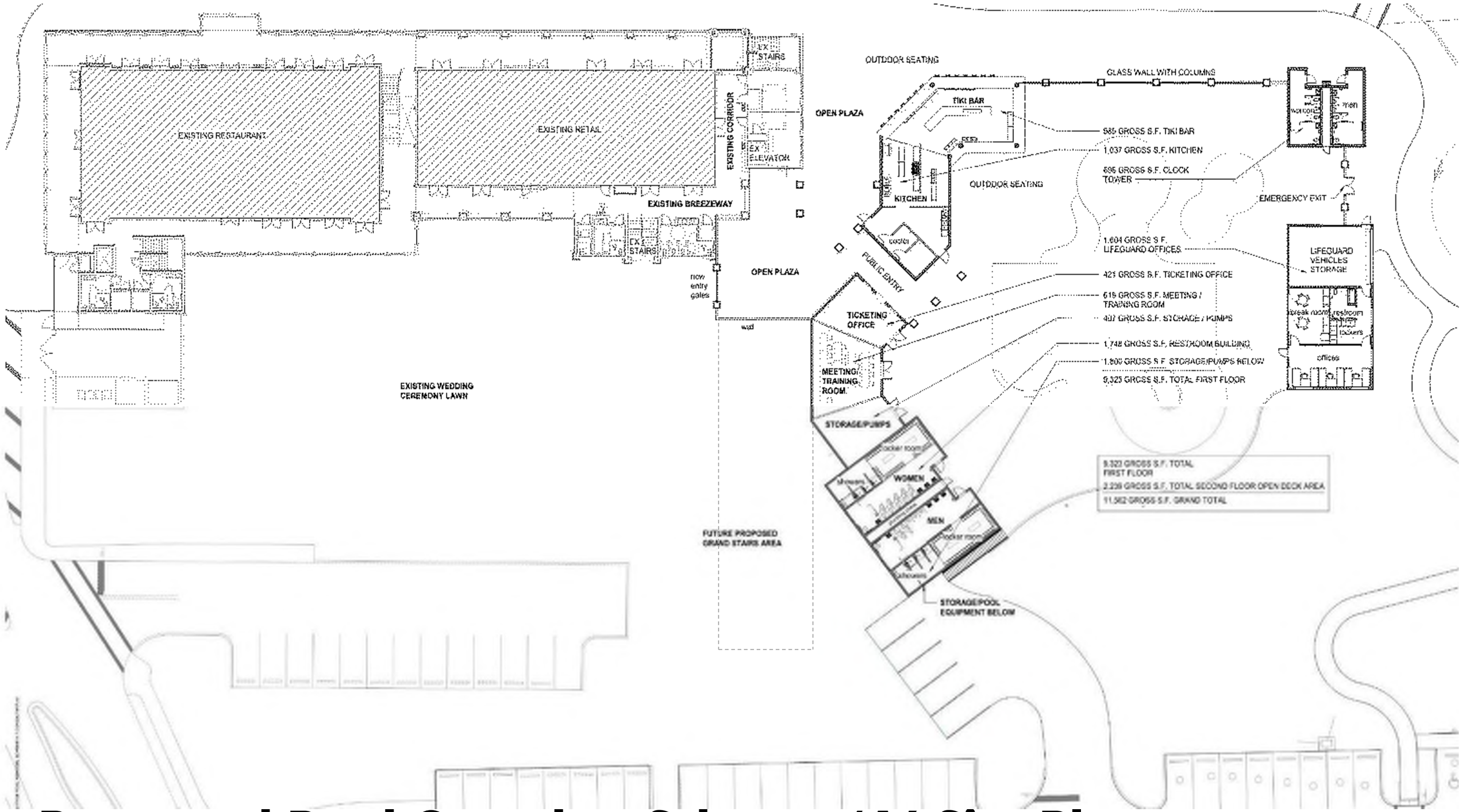
Glass Wall

Lifeguard Building

Shallow Pool Seating Area

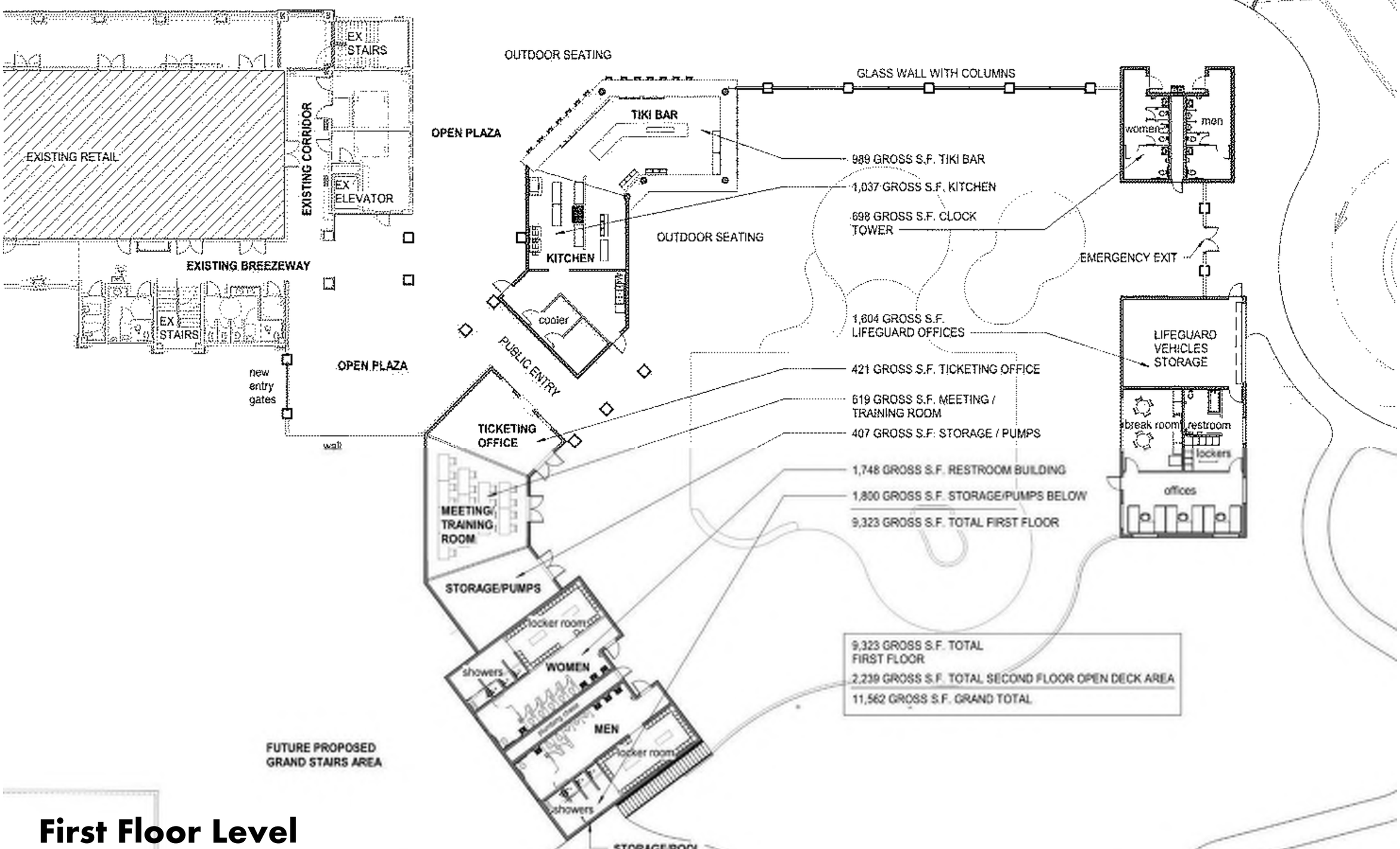
Sunset View

Service below



Proposed Pool Complex Scheme 'A' Site Plan

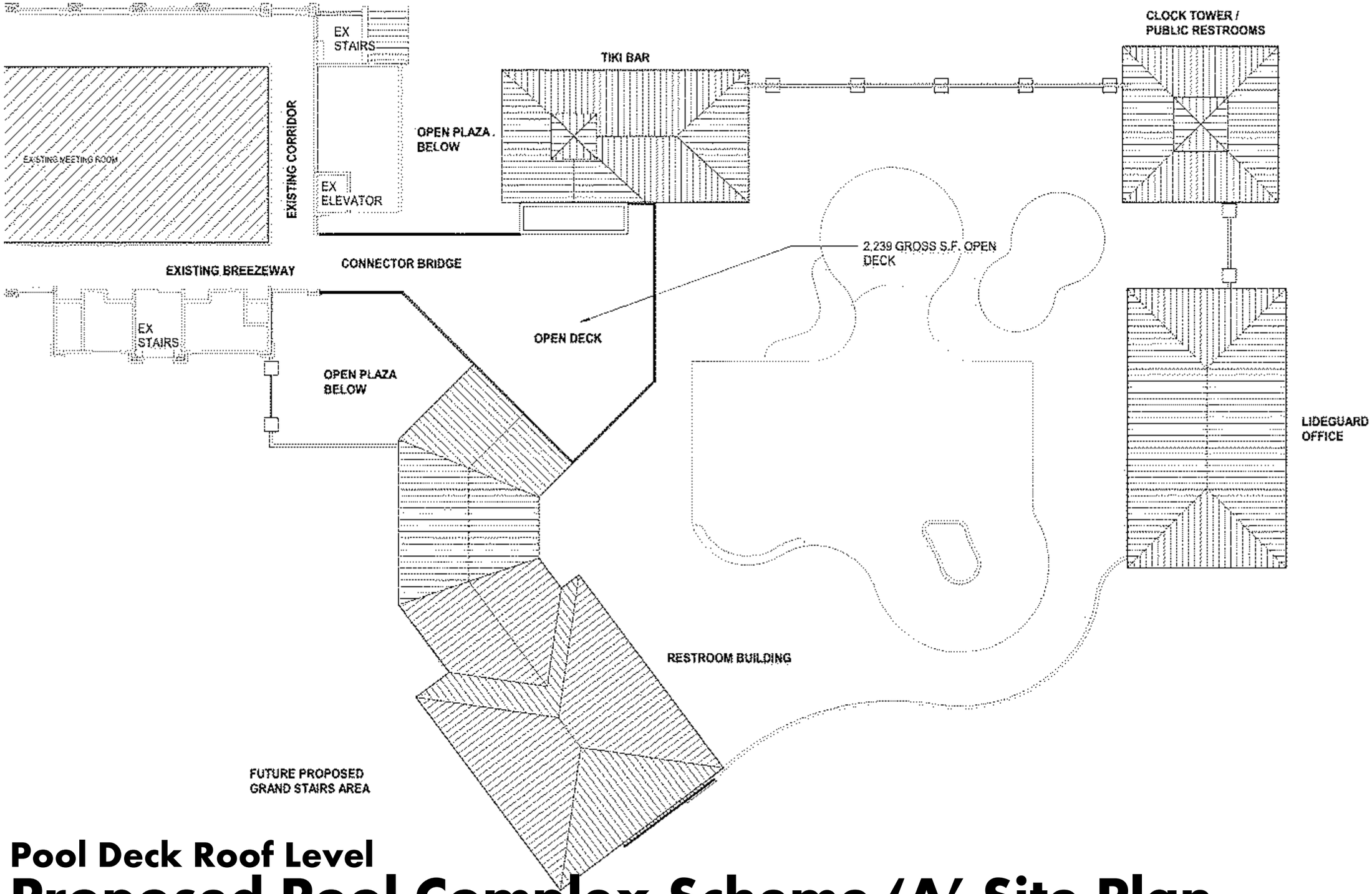
CPZ Architects | KEITH | Aquatic Consulting Engineers



First Floor Level

Proposed Pool Complex Scheme 'A' Site Plan

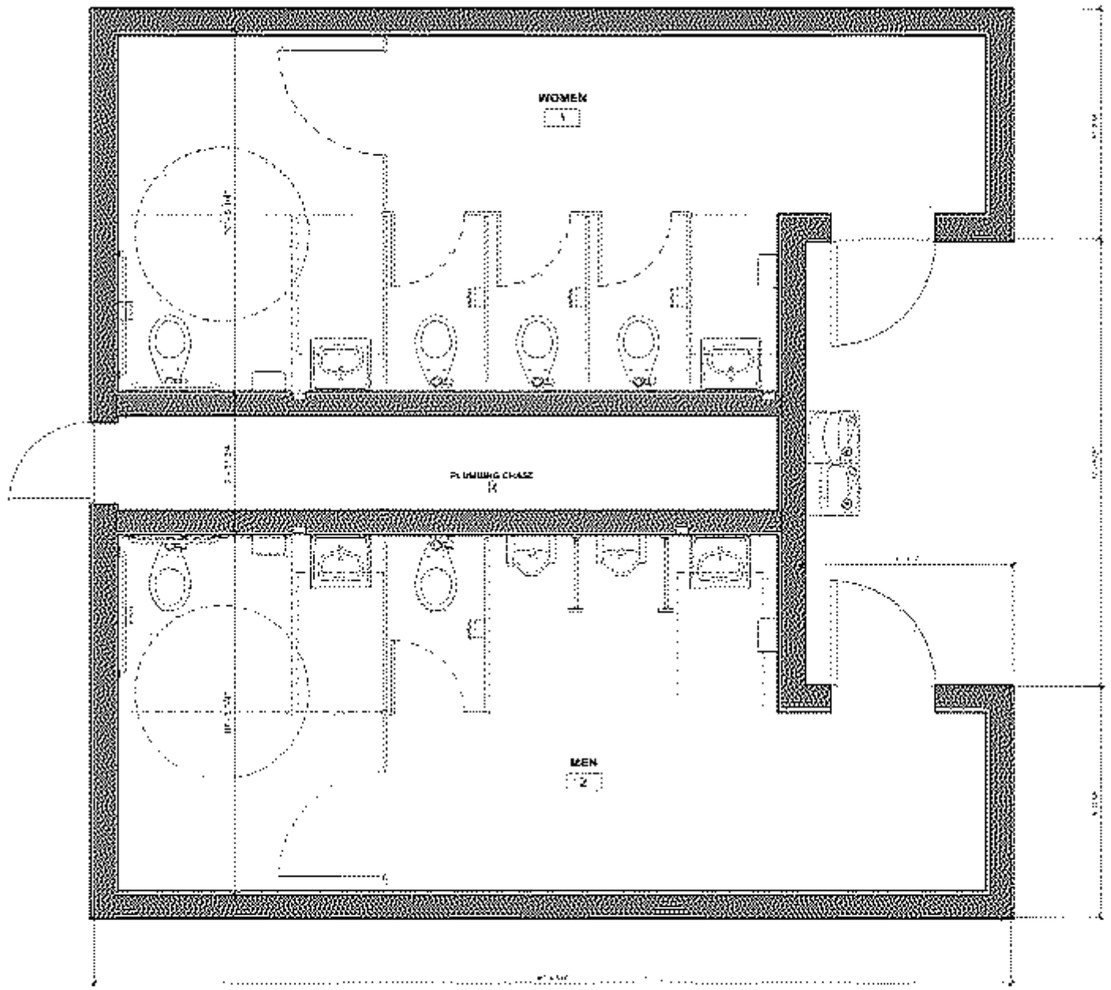
CPZ Architects | KEITH | Aquatic Consulting Engineers



Pool Deck Roof Level

Proposed Pool Complex Scheme ‘A’ Site Plan

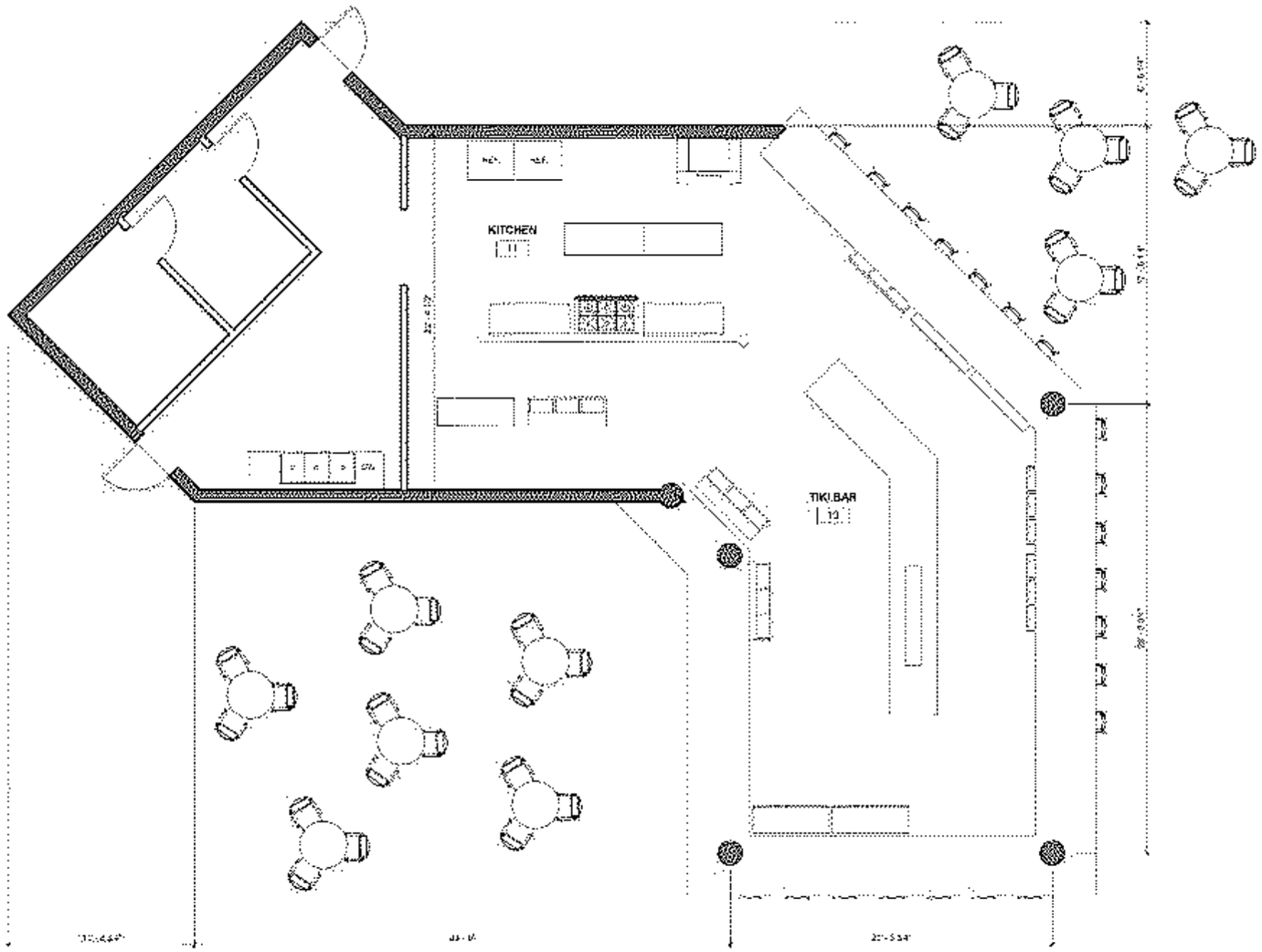
Proposed Clock Tower / Public Restrooms Building
Floor Plan Scheme ‘A’



1 CLOCK TOWER / PUBLIC RESTROOMS BUILDING

698 S.F. CLOCK TOWER.

Proposed Tiki Bar Building Floor Plan Scheme ‘A’



TIKI BAR BUILDING SCHEME A

989 S.F. TIKI BAR.
1037 S.F. KITCHEN

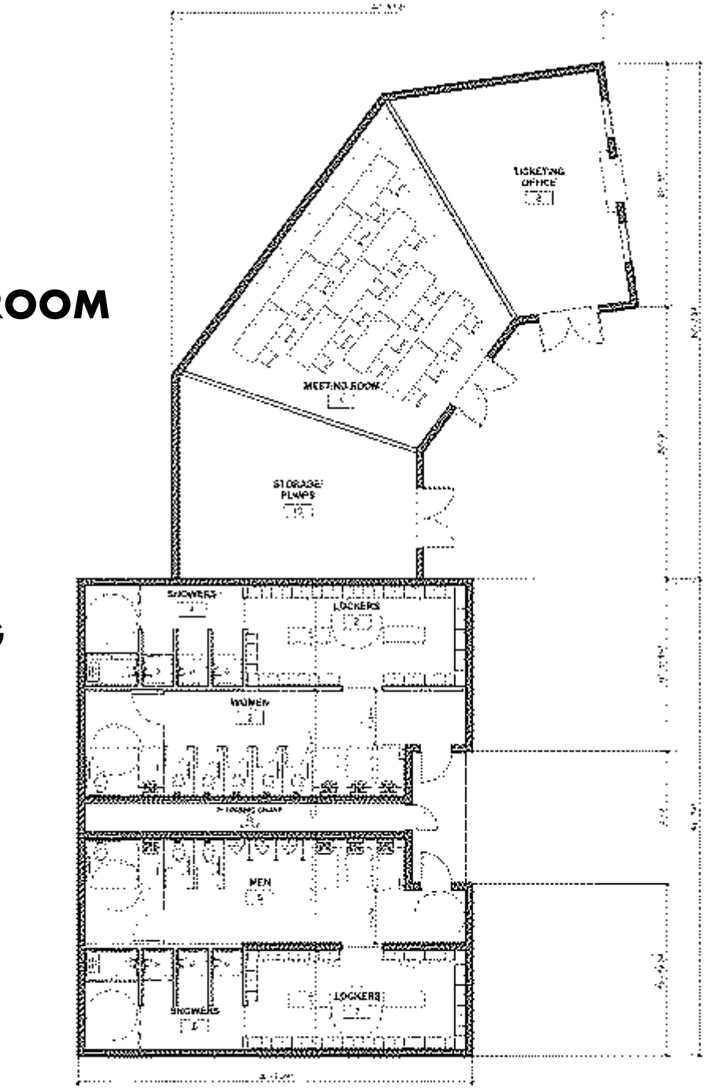
Proposed Meeting Room/ Restrooms Building/ Pool Equipment & Storage below Floor Plan Scheme ‘A’

421 S.F. TICKETING OFFICE

619 S.F. MEETING/ TRAINING ROOM

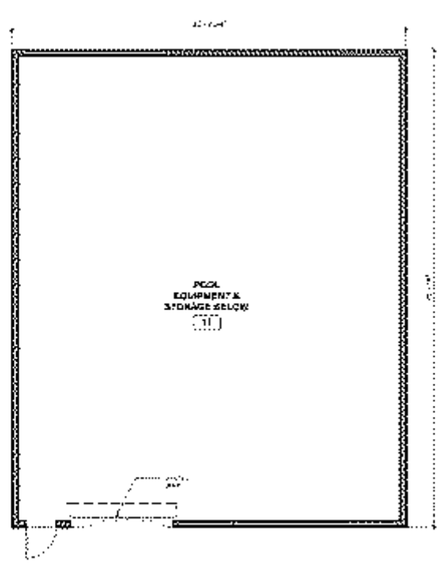
407 S.F. STORAGE PUMPS.

1748 S.F. RESTROOM BUILDING



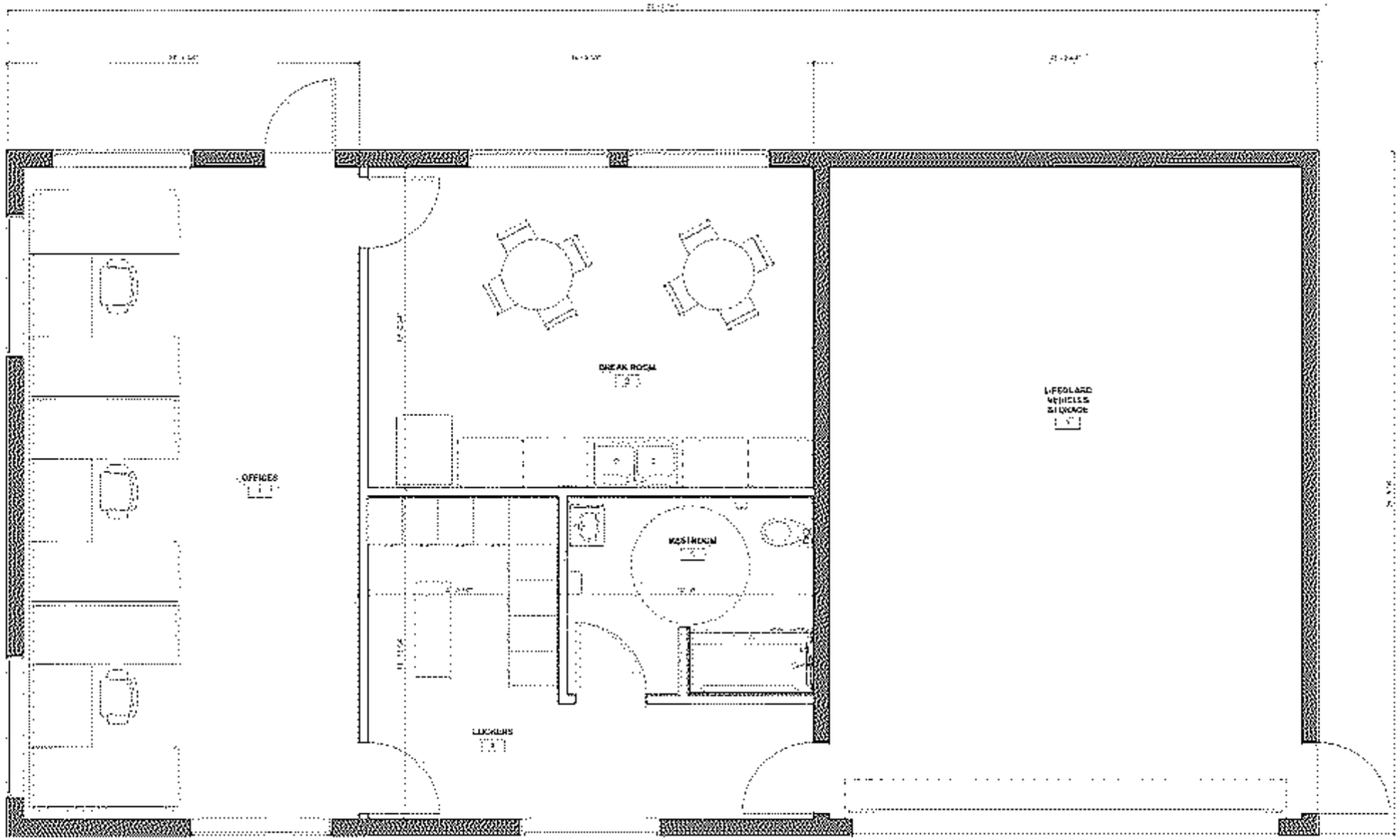
MEETING ROOM / RESTROOMS BUILDING / POOL EQUIPMENT & STORAGE BELOW SCHEME A

1800 S.F. POOL EQUIPMENT & STORAGE BELOW



POOL EQUIPMENT & STORAGE BELOW SCHEME A

Proposed Lifeguard Building Floor Plan Scheme ‘A’

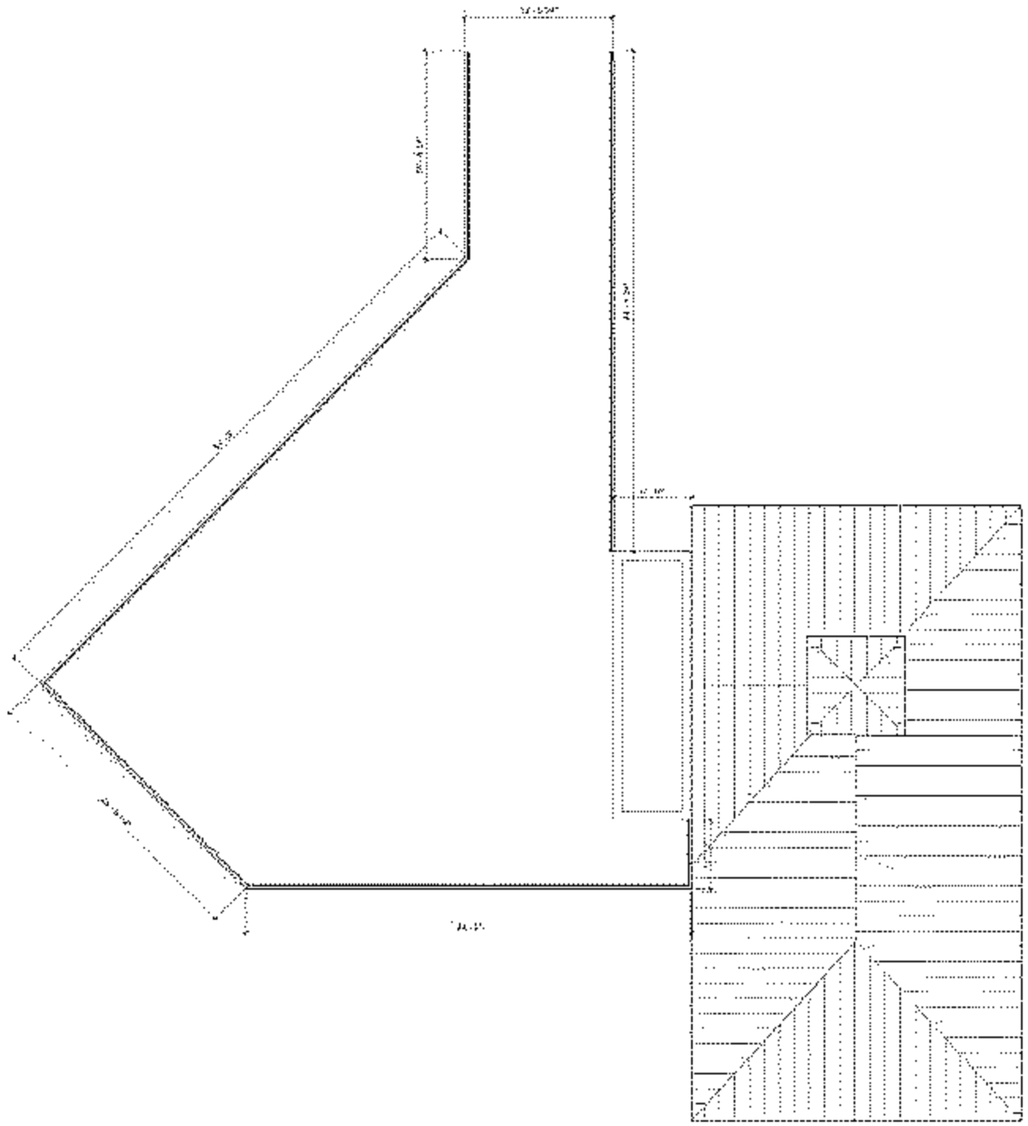


1 LIFEGUARD BUILDING SCHEME A

1604 S.F. LIFEGUARD BUILDING.

CPZ Architects | KEITH | Aquatic Consulting Engineers

Proposed Second Floor Deck Plan Scheme ‘A’



SECOND FLOOR DECK SCHEME A **2239 S.F. OPEN DECK**

CPZ Architects | KEITH | Aquatic Consulting Engineers

CPZ Architects | KEITH | Aquatic Consulting Engineers

Scheme A
OPINION OF COST

CMS-Construction Management Services, Inc.
10 Fairway Drive, Suite 301
Deerfield Beach, Fl 33441
954-481-1611
CMS FILE # 2354 ORDER OF MAGNITUDE

POOL COMPLEX REMODEL
LAKE WORTH CASINO
10 S OCEAN BLVD
LAKE WORTH, FLORIDA 33460

ORDER OF MAGNITUDE
COST ESTIMATE (rev 2)
August 13, 2019

PREPARED FOR:
CPZ ARCHITECTS

SCHEDULE OF VALUES

DIVISION	DESCRIPTION	SCHEME A - BASE	SCHEME A - LIFEGUARD BUILDING	SCHEME A - MEETING ROOM	SCHEME A - 2ND FLOOR DECK	SCHEME A - TIKI BAR BUILDING	SCHEME A - CLOCK TOWER / PUBLIC RESTROOMS
		AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT
01000	GENERAL CONDITIONS - SEE BREAKOUT BELOW	$ -	$ -	$ -	$ -	$ -	$ -
02000	SITE WORK / DEMOLITION	$ 731,906	$ -	$ -	$ -	$ -	$ -
03000	CONCRETE	$ 724,925	$ 120,900	$ 48,475	$ 167,925	$ 151,950	$ 52,350
04000	MASONRY	$ 90,903	$ 12,630	$ 4,840	$ -	$ 13,705	$ 8,235
05000	METALS	$ 46,615	$ 8,650	$ 3,995	$ 30,000	$ 10,130	$ 3,499
06000	WOOD AND PLASTICS	$ 33,308	$ 4,510	$ 1,399	$ 5,060	$ 3,065	$ 1,745
07000	THERMAL / MOISTURE PROTECTION	$ 233,975	$ 24,660	$ 9,295	$ -	$ 30,390	$ 18,479
08000	DOORS AND WINDOWS	$ 455,745	$ 24,660	$ 9,295	$ -	$ 30,390	$ 18,479
09000	FINISHES	$ 566,905	$ 40,100	$ 15,475	$ -	$ 50,650	$ 17,466
10000	SPECIALTIES / SIGNAGE	$ 45,900	$ -	$ -	$ -	$ -	$ -
11000	EQUIPMENT	$ -	$ -	$ -	$ -	$ -	$ -
12000	FURNISHINGS	$ -	$ -	$ -	$ -	$ -	$ -
13000	SPECIAL CONSTRUCTION	$ 1,287,175	$ -	$ -	$ -	$ -	$ -
14000	CONVEYING SYSTEMS	$ -	$ -	$ -	$ -	$ -	$ -
21000	FIRE	$ 27,900	$ 4,812	$ 1,857	$ -	$ 6,078	$ 3,094
22000	PLUMBING	$ 235,000	$ 15,000	$ -	$ 27,000	$ 49,000	$ 79,000
23000	HVAC	$ 45,885	$ 10,400	$ 5,100	$ -	$ 24,055	$ -
26000	ELECTRICAL	$ 169,845	$ 24,660	$ 9,295	$ 15,795	$ 30,390	$ 18,479
27000	TECHNOLOGY	$ -	$ -	$ -	$ -	$ -	$ -
28000	ELECTRONIC SAFETY & SECURITY	$ -	$ -	$ -	$ -	$ -	$ -
31000	SITE WORK, EARTHWORK, ASPHALT PAVING, SIDE WALKS	$ 400,394	$ -	$ -	$ -	$ -	$ -
32000	EXTERIOR IMPROVEMENTS	$ 407,000	$ -	$ -	$ 33,975	$ -	$ -
33000	SITE UTILITIES	$ 207,900	$ -	$ -	$ -	$ -	$ -
	SUBTOTAL'S: DIRECTHARD COSTS	$ 5,765,985	$ 280,942	$ 108,909	$ 303,740	$ 456,233	$ 188,774
12.00%	GENERAL CONDITIONS	$ 692,279	$ 34,453	$ 12,800	$ 36,449	$ 48,028	$ 22,653
	SUBTOTAL	$ 6,461,266	$ 321,379	$ 119,771	$ 340,189	$ 498,261	$ 211,427
4.00%	O.C. OVERHEAD	$ 258,451	$ 12,855	$ 4,791	$ 13,608	$ 17,930	$ 8,457
	SUBTOTAL	$ 6,719,719	$ 334,234	$ 124,562	$ 353,797	$ 466,191	$ 219,884
6.00%	O.C. PROFIT	$ 403,183	$ 20,054	$ 7,474	$ 21,228	$ 27,971	$ 13,193
	SUBTOTAL	$ 7,122,902	$ 354,288	$ 132,036	$ 375,026	$ 494,163	$ 233,077
1.29%	O.C. P&P BOND	$ 91,886	$ 4,570	$ 1,703	$ 4,838	$ 6,375	$ 3,007
	SUBTOTAL	$ 7,214,787	$ 358,858	$ 133,739	$ 379,862	$ 500,538	$ 236,084
5.00%	ESCALATION (ALLOWANCE)	$ 360,739	$ 17,943	$ 6,687	$ 18,993	$ 25,027	$ 11,804
	SUBTOTAL	$ 7,575,527	$ 376,797	$ 140,426	$ 398,855	$ 525,564	$ 247,888
20.00%	CONTINGENCY	$ 1,515,105	$ 75,359	$ 28,085	$ 79,771	$ 105,113	$ 49,578
	TOTAL PROBABLE CONSTRUCTION COST	$ 9,090,632	$ 452,156	$ 168,511	$ 478,626	$ 630,677	$ 297,466

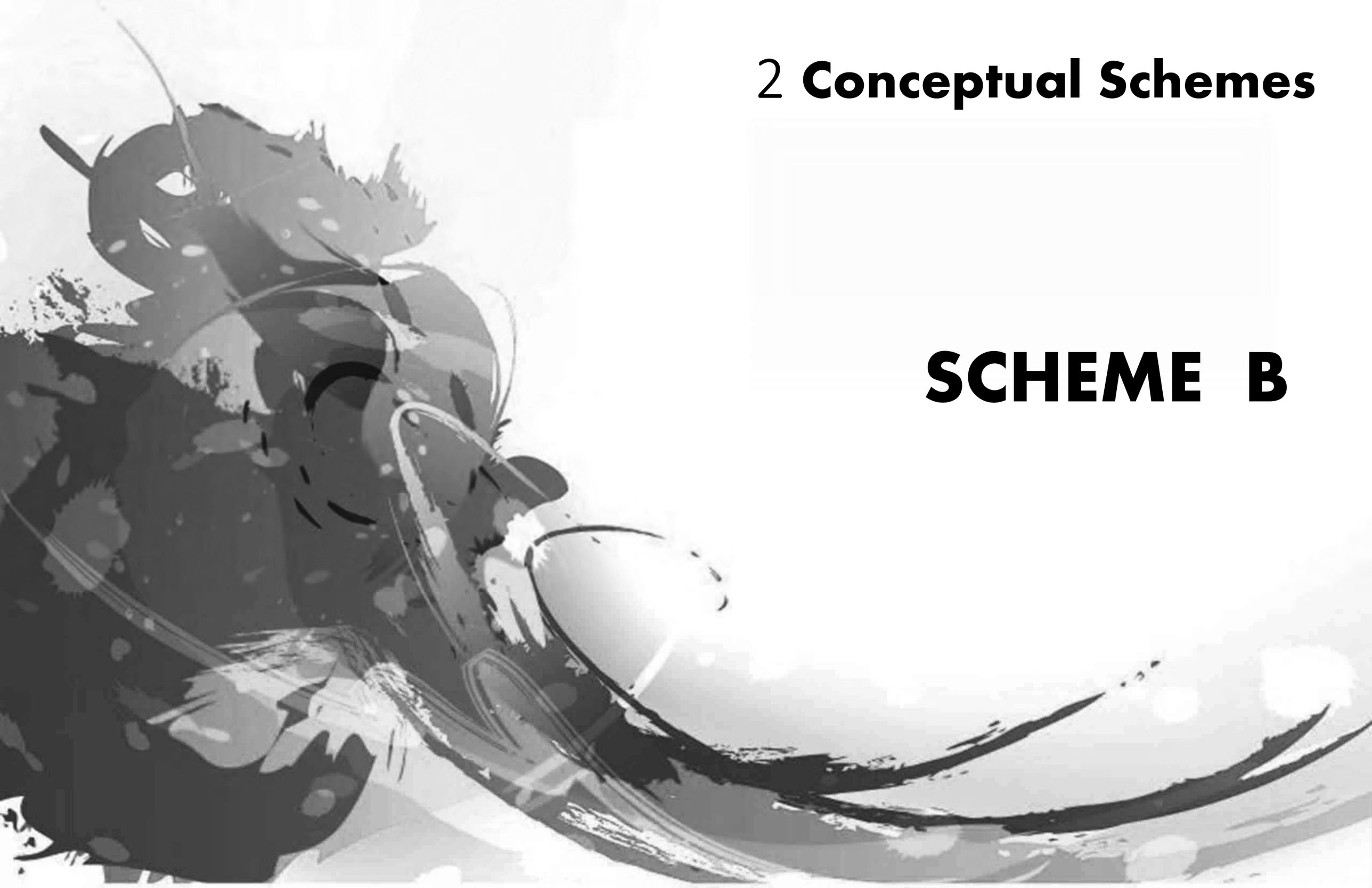
Scheme A
OPINION OF COST

DIVISION	DESCRIPTION	SCHEME A - BASE	SCHEME A - LIFEGUARD BUILDING	SCHEME A - MEETING ROOM	SCHEME A - 2ND FLOOR DECK	SCHEME A - TIKI BAR BUILDING	SCHEME A - CLOCK TOWER / PUBLIC RESTROOMS
		AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT
12.00%	GENERAL CONDITIONS	$ 992,279	$ 34,433	$ 12,833	$ 36,449	$ 48,028	$ 22,653
	SUBTOTAL	$ 8,465,268	$ 321,375	$ 119,771	$ 340,189	$ 448,281	$ 211,427
4.00%	G.C. OVERHEAD	$ 258,451	$ 12,855	$ 4,791	$ 13,608	$ 17,930	$ 8,457
	SUBTOTAL	$ 8,719,719	$ 334,230	$ 124,562	$ 353,797	$ 466,191	$ 219,884
6.00%	G.C. PROFIT	$ 403,183	$ 20,054	$ 7,474	$ 21,228	$ 27,971	$ 13,193
	SUBTOTAL	$ 7,122,902	$ 354,284	$ 132,036	$ 375,024	$ 494,163	$ 233,077
1.29%	G.C. P&P BOND	$ 91,885	$ 4,570	$ 1,703	$ 4,838	$ 6,375	$ 3,007
	SUBTOTAL	$ 7,214,787	$ 358,854	$ 133,739	$ 379,862	$ 500,538	$ 236,084
5.00%	ESCALATION (ALLOWANCE)	$ 360,739	$ 17,943	$ 6,687	$ 18,993	$ 25,027	$ 11,804
	SUBTOTAL	$ 7,575,527	$ 376,797	$ 140,426	$ 398,855	$ 525,564	$ 247,888
20.00%	CONTINGENCY	$ 1,515,105	$ 75,359	$ 28,085	$ 79,771	$ 105,113	$ 49,578
	TOTAL PROBABLE CONSTRUCTION COST	$ 9,090,633	$ 452,156	$ 168,511	$ 478,626	$ 630,677	$ 297,465

Scheme A
OPINION OF COST

Scheme "A"			
		Deduct	**Total**
	Total Cost		**$9,090,632**
	Deductions:		
	Second Floor Deck	$478,626	$8,612,006
	Lifeguard Building	$452,156	$8,159,850
	Meeting Room	$168,511	**$7,991,339**
	Tiki Bar Building	$630,677	$7,360,662
	Clock Tower/ Public Restrooms Building	$297,465	$7,063,197

SCHEME B



CPZ Architects | KEITH | Aquatic Consulting Engineers

Scheme B

Glass Wall

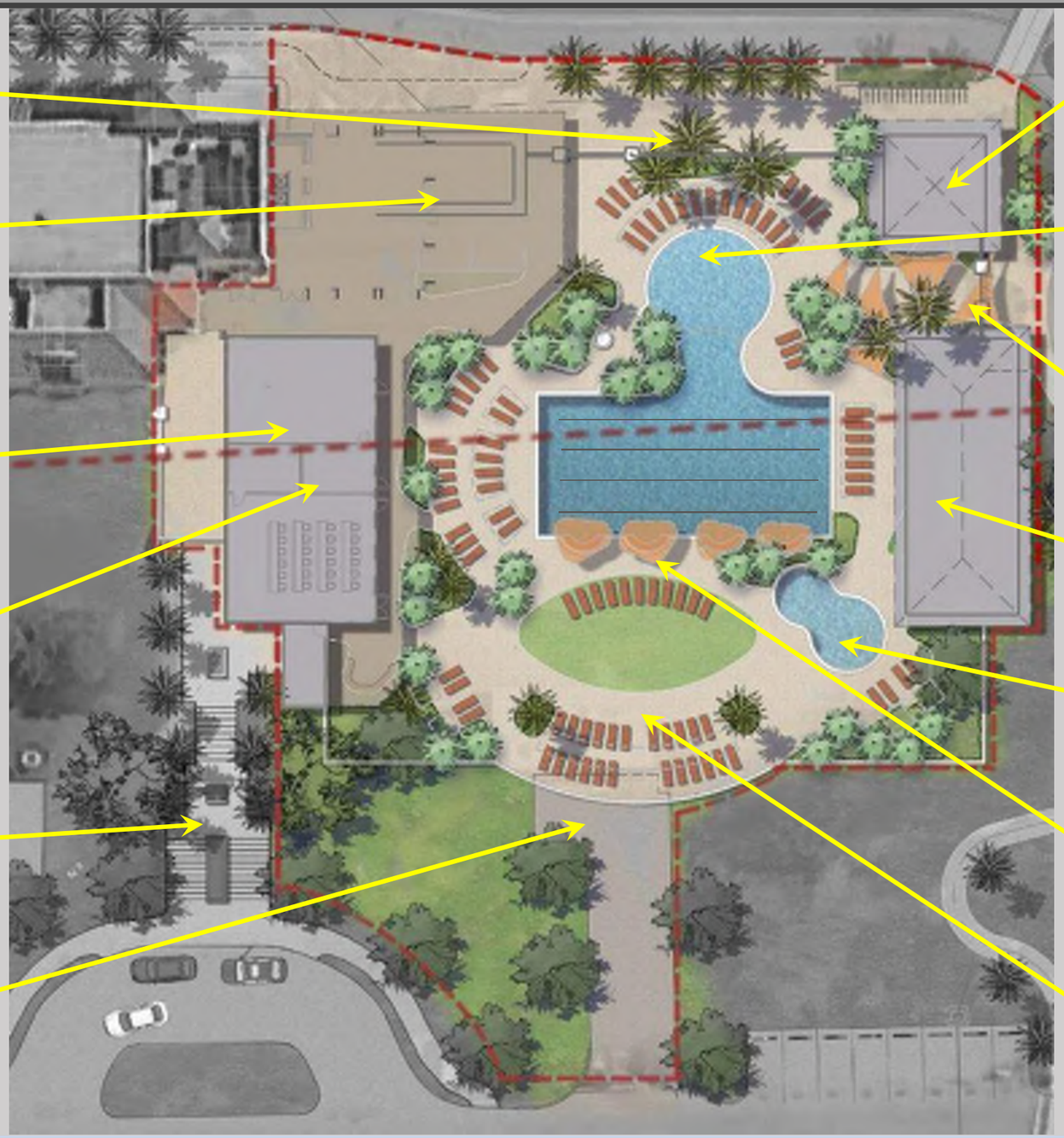
Tiki Bar

Staff and Meeting Room, 2nd FL

1st FL Restroom

Future Stair and Drop Off

Service Below



Public Restroom

Zero Entry Pool

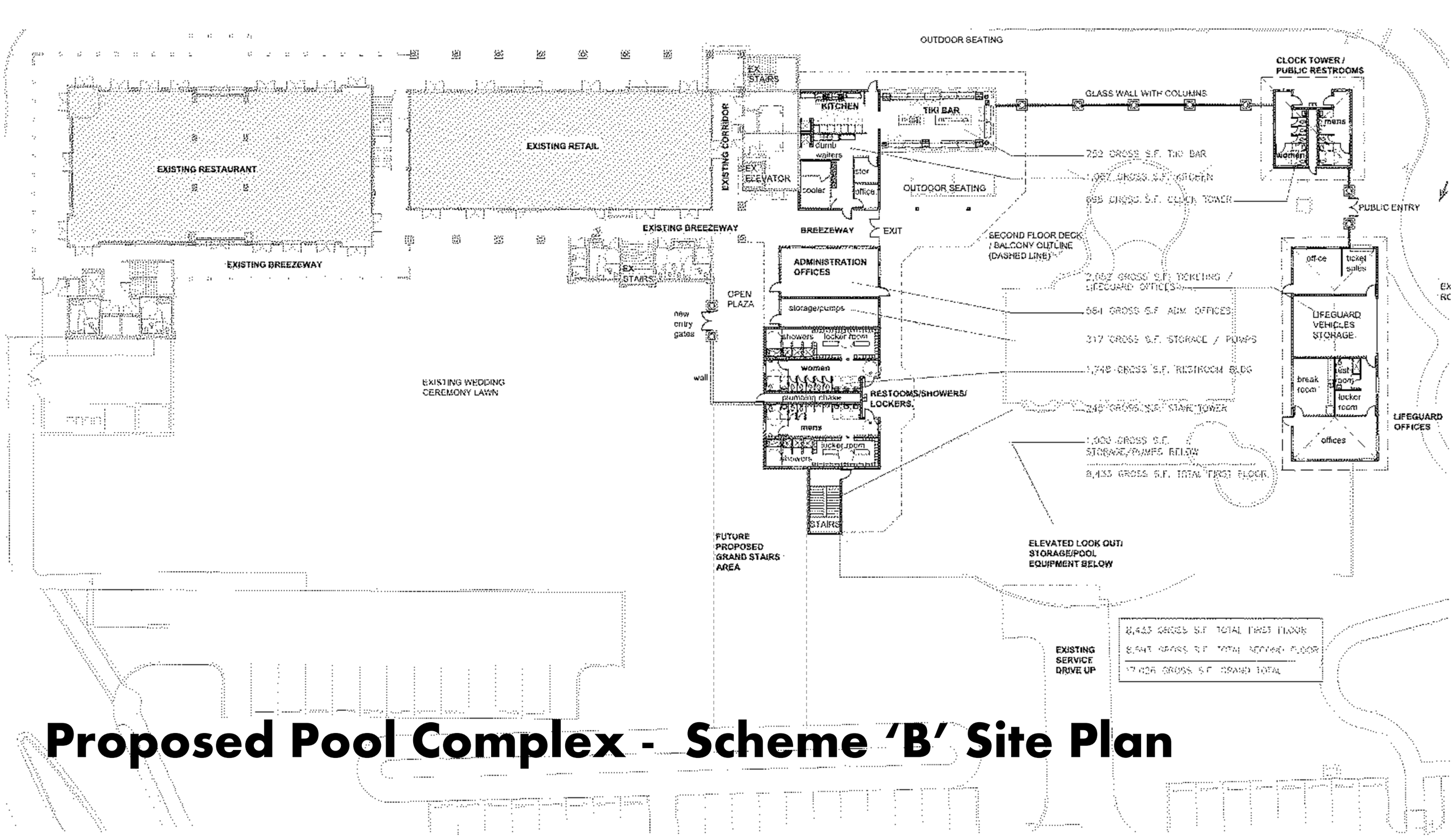
Pool Entry

Lifeguard Building

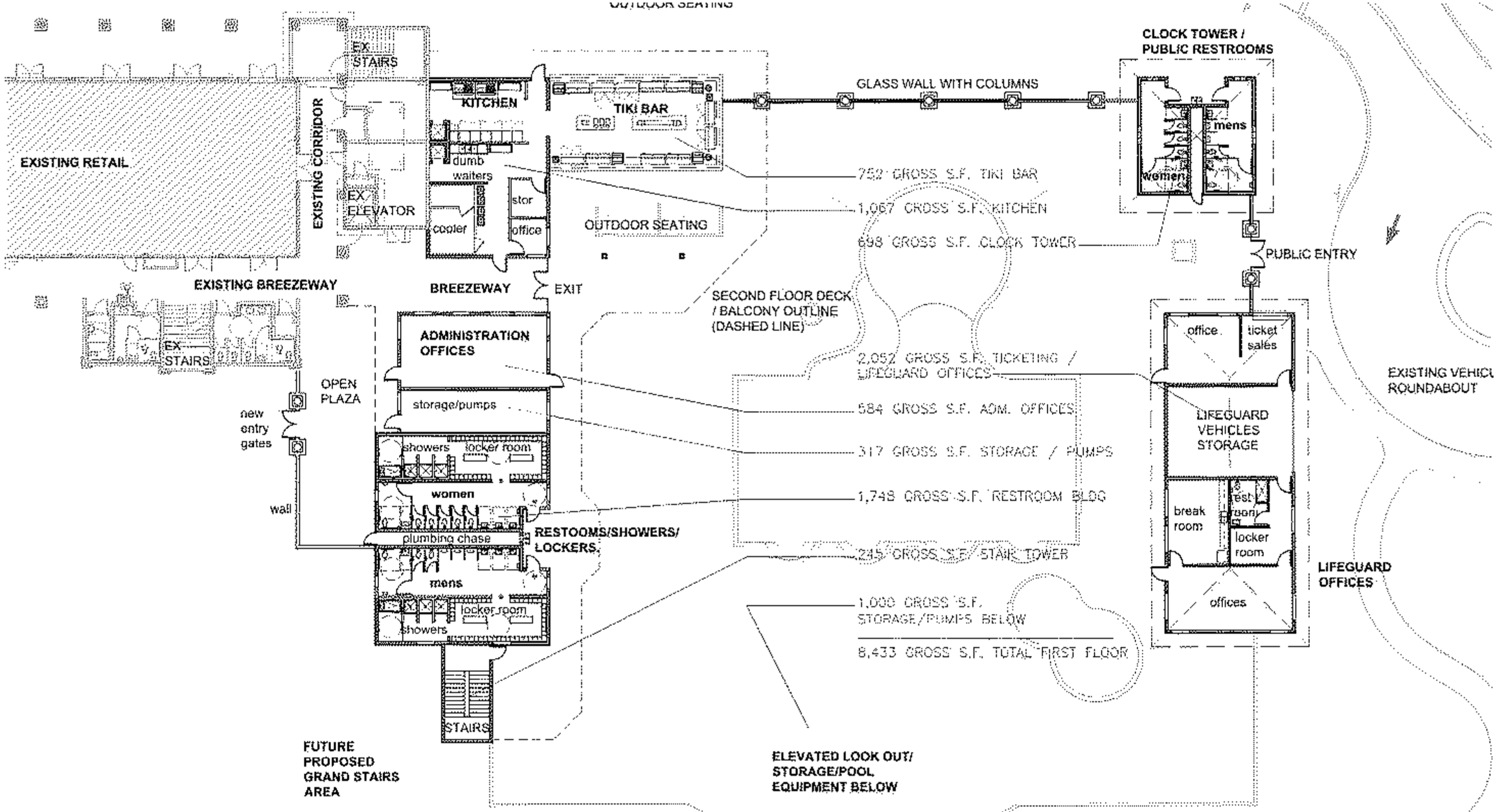
Splash Pad

Pool Seating

Sunset View

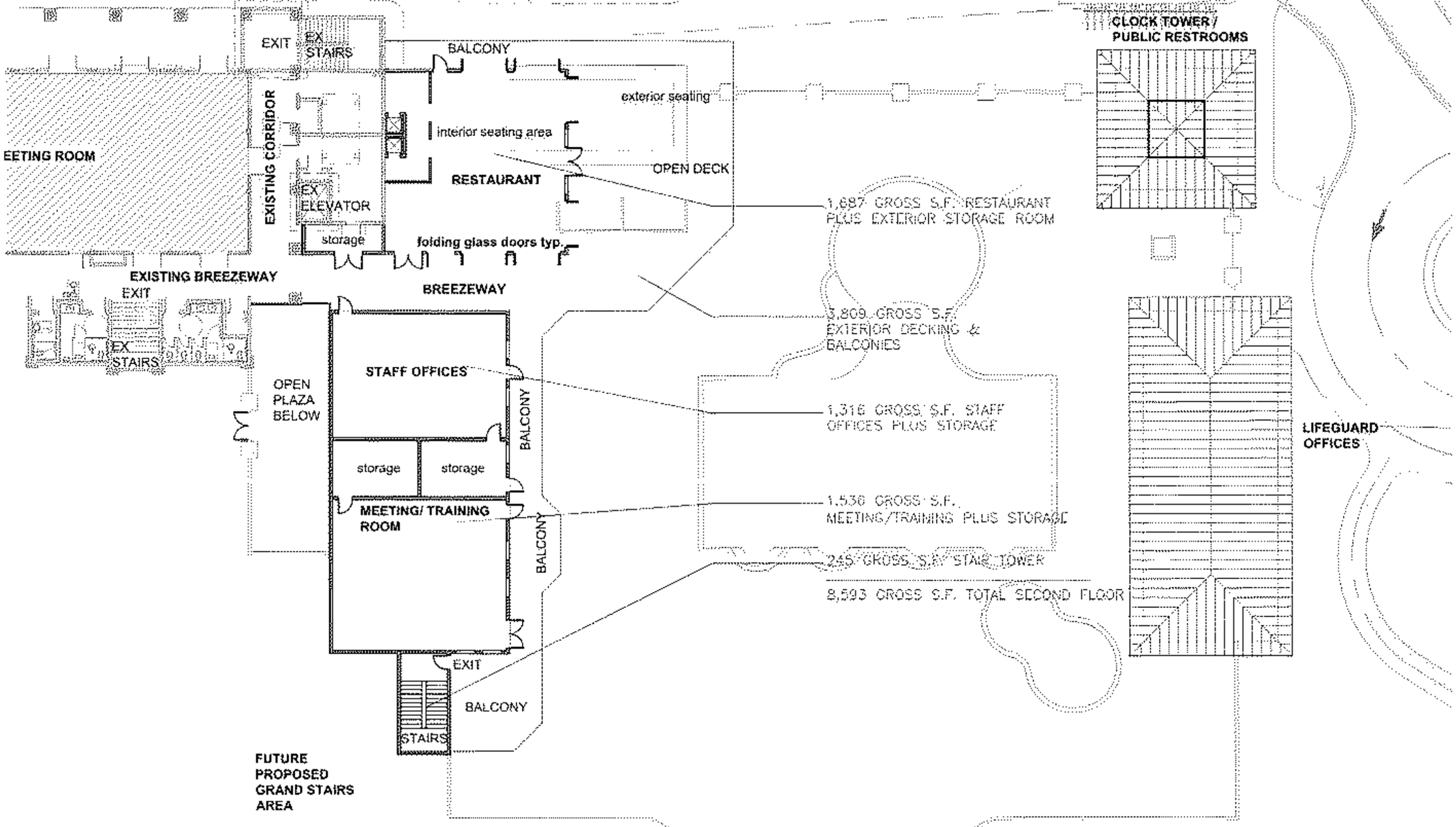


Proposed Pool Complex - Scheme 'B' Site Plan



Proposed Pool Complex - Scheme 'B' Site Plan

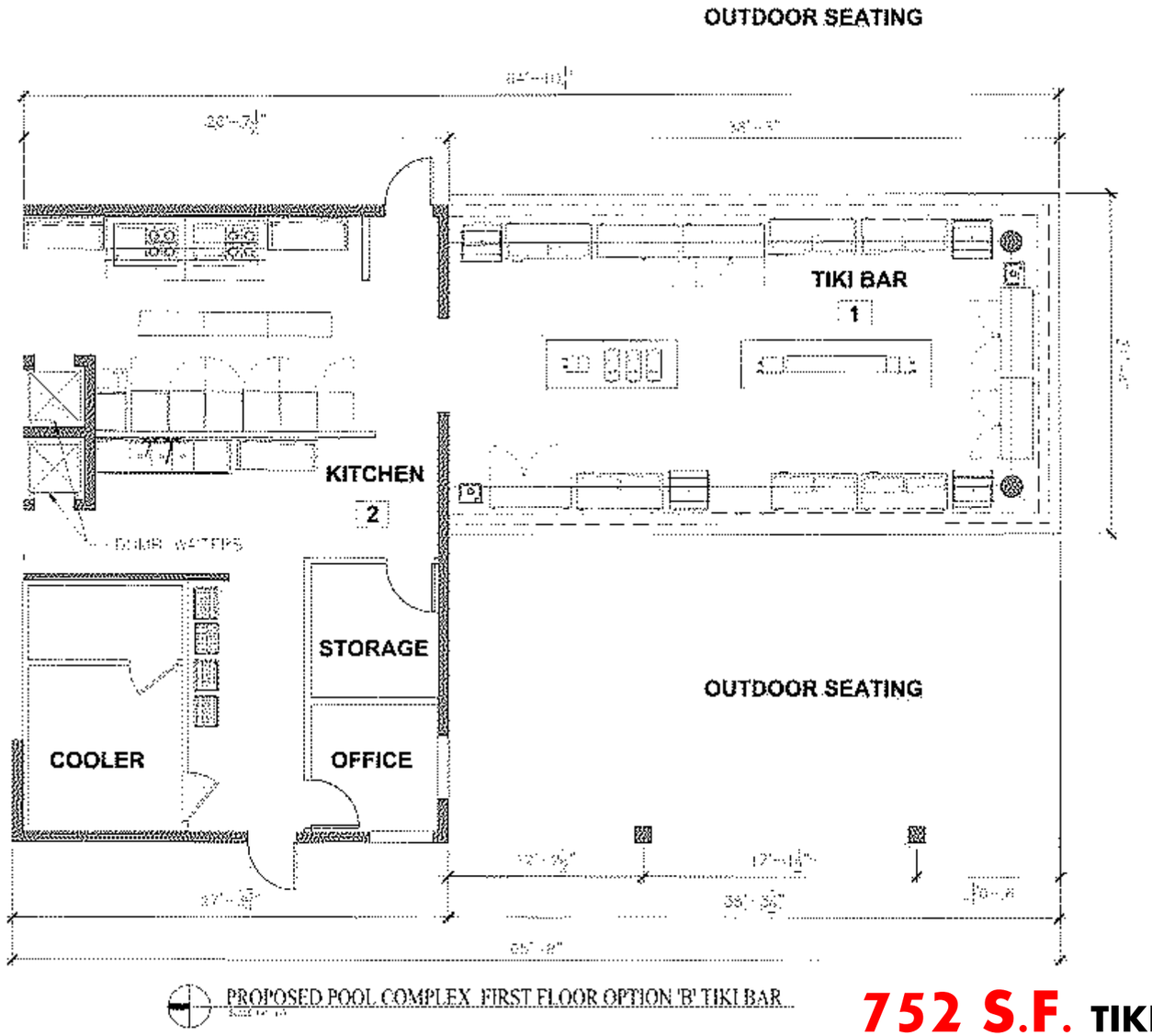
Pool Deck Ground Level



Proposed Pool Complex Scheme ‘B’ Site Plan

Second Floor Level

Proposed Tiki Bar Floor Plan Scheme ‘B’

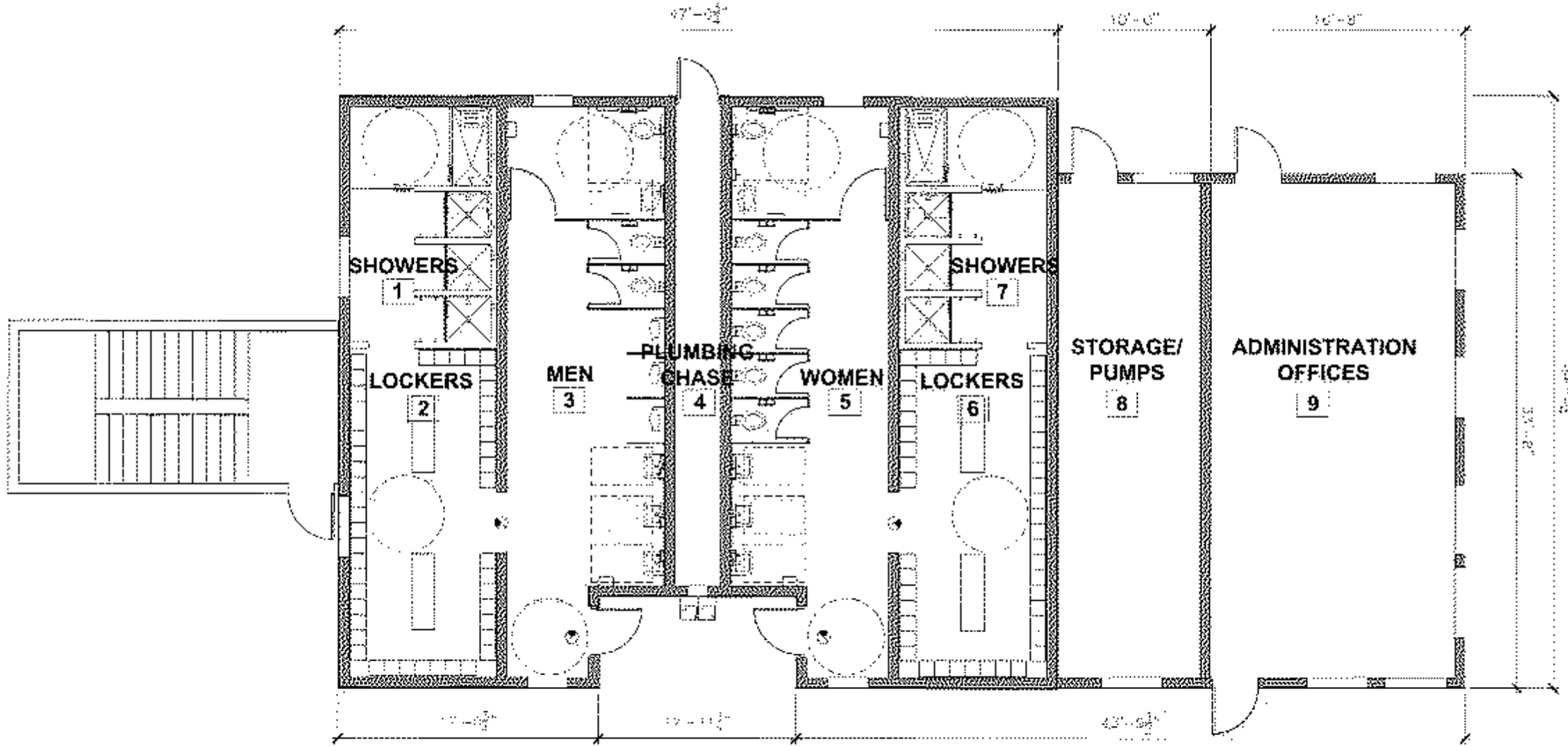


PROPOSED POOL COMPLEX FIRST FLOOR OPTION 'B' TIKI BAR

752 S.F. TIKI BAR

1067 S.F. KITCHEN

Proposed Administration / Restroom Building Floor Plan Scheme 'B'



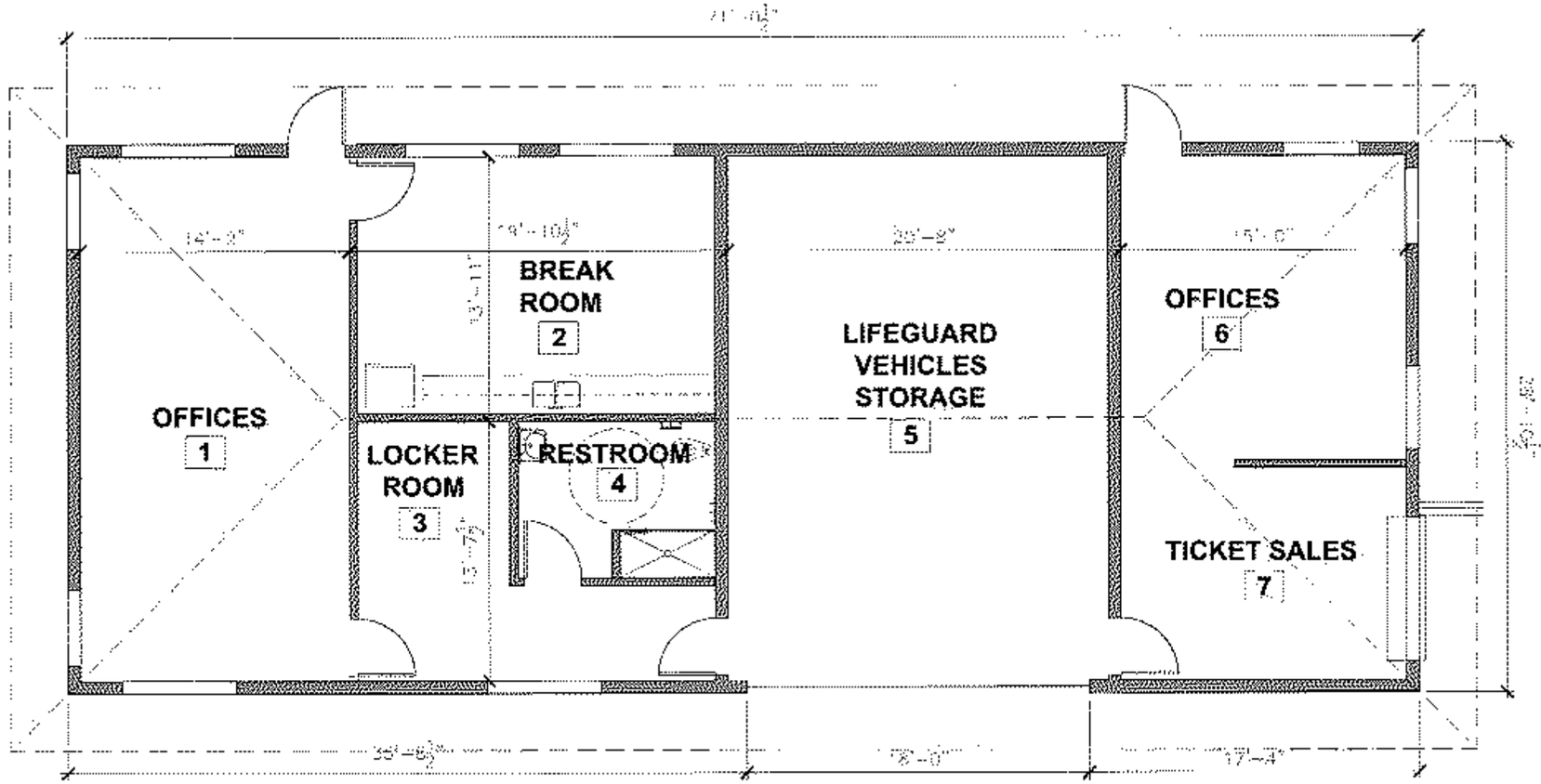
PROPOSED POOL COMPLEX FIRST FLOOR OPTION 'B' SHOWERS/ LOCKER ROOM

584 S.F. ADM. OFFICES

317 S.F. STORAGE PUMPS

245 S.F. STAIR TOWER **1748 S.F.** RESTROOM BUILDING

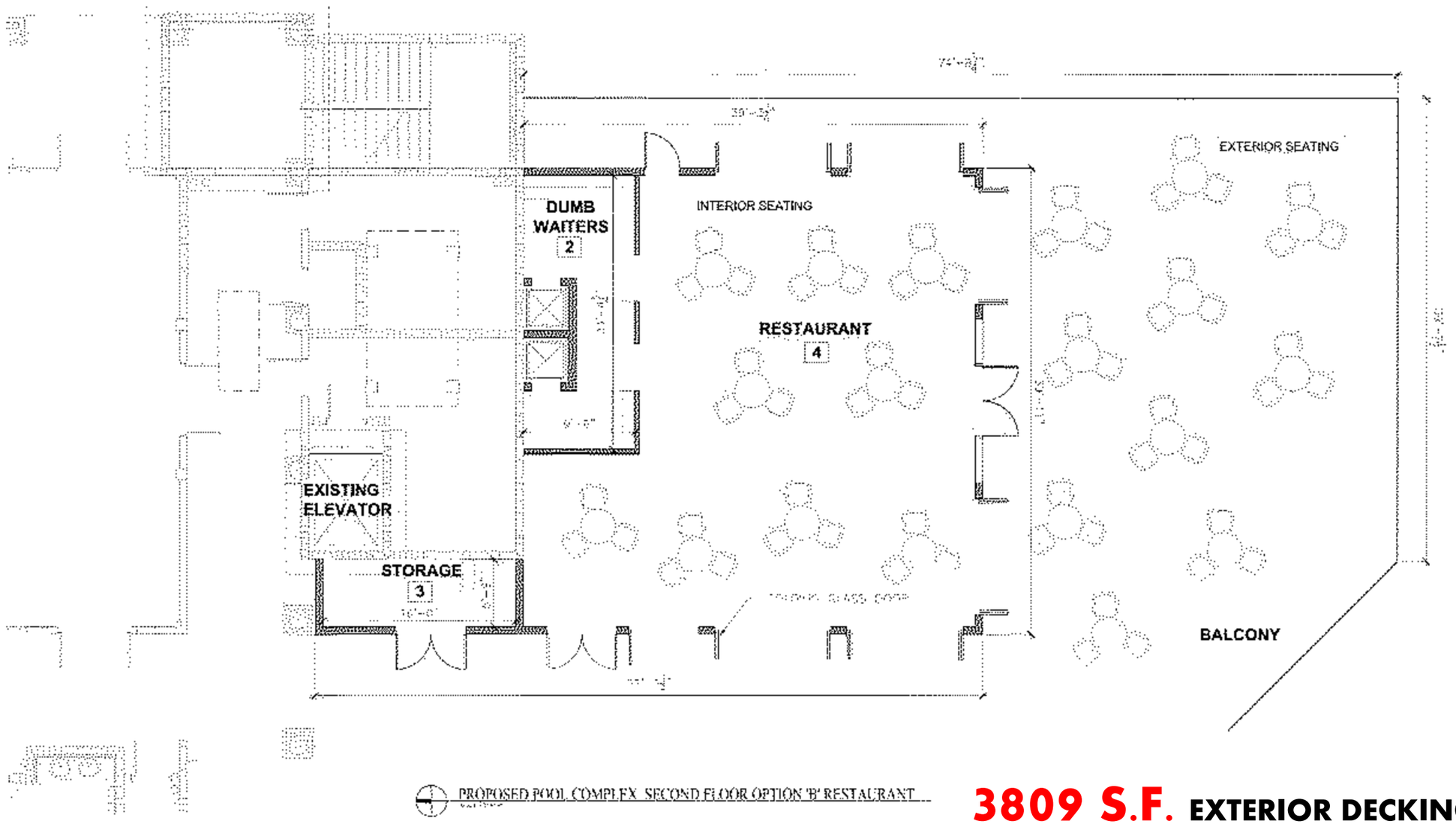
Proposed Ticketing / Lifeguard Building Floor Plan Scheme 'B'



PROPOSED POOL COMPLEX FIRST FLOOR OPTION 'B' LIFEGUARD OFFICES

2052 S.F. LIFEGUARD BUILDING

Proposed Second Floor Restaurant / Exterior Deck Plan Scheme 'B'

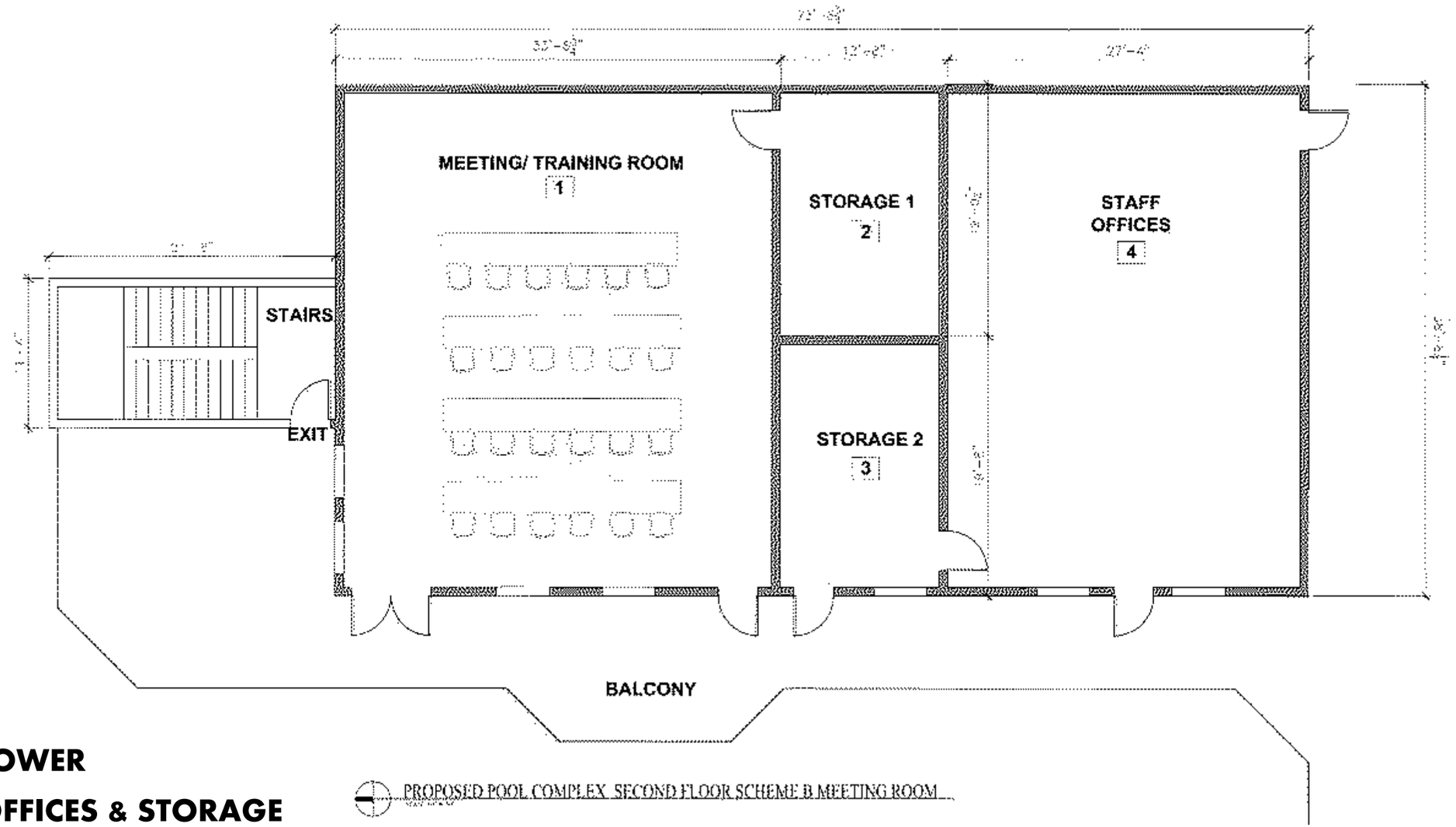


PROPOSED POOL COMPLEX SECOND FLOOR OPTION 'B' RESTAURANT

3809 S.F. EXTERIOR DECKING & BALCONY

1687 S.F. RESTAURANT

Proposed Second Floor Offices / Meeting Room & Balconies Plan Scheme 'B'



PROPOSED POOL COMPLEX SECOND FLOOR SCHEME B MEETING ROOM

245 S.F. STAIR TOWER

1316 S.F. STAFF OFFICES & STORAGE

1536 S.F. MEETING/ TRAINING ROOM & STORAGE

CPZ Architects | KEITH | Aquatic Consulting Engineers

CPZ Architects | KEITH | Aquatic Consulting Engineers

Scheme B

OPINION OF COST

CMS-Construction Management Services, Inc.
10 Fairway Drive, Suite 301
Deerfield Beach, Fl 33441
954-481-1611
CMS FILE # 2264 ORDER OF MAGNITUDE

POOL COMPLEX REMODEL
LAKE WORTH CASINO
10 S OCEAN BLVD
LAKE WORTH, FLORIDA 33460

ORDER OF MAGNITUDE
COST ESTIMATE (rev 2)
August 13, 2019

PREPARED FOR:
CPZ ARCHITECTS

SCHEDULE OF VALUES

DIVISION	DESCRIPTION	SCHEME B - BASE AMOUNT	SCHEME B - TIKI BAR AMOUNT	SCHEME B : 2ND FLOOR RESTAURANT / EXT DECK AMOUNT	SCHEME B - 2ND FLOOR OFFICES / MEETING ROOMS / BALCONIES AMOUNT	SCHEME B - TICKETING / LIFEGUARD BUILDING AMOUNT	SCHEME B - CLOCK TOWER / PUBLIC RESTROOMS AMOUNT
01000	GENERAL CONDITIONS - SEE BREAKOUT BELOW	$ -	$ -	$ -	$ -	$ -	$ -
02000	SITE WORK / DEMOLITION	731,536	0	0	0	0	$ -
03000	CONCRETE	1,353,075	136,435	136,935	213,900	153,900	$ 32,350
04000	MASONRY	127,695	11,643	12,403	21,390	15,390	$ 5,295
05000	METALS	85,130	9,095	8,435	14,260	10,260	$ 3,490
06000	WOOD AND PLASTICS	85,130	4,548	4,218	7,130	5,130	$ 1,745
07000	THERMAL / MOISTURE PROTECTION	425,650	27,285	25,305	42,780	30,780	$ 10,470
08000	DOORS AND WINDOWS	319,238	27,285	25,305	42,780	30,780	$ 10,470
09000	FINISHES	419,525	45,475	42,175	71,300	51,300	$ 17,450
10000	SPECIALTIES / SIGNAGE	45,909	0	0	0	0	$ -
11000	EQUIPMENT	0	0	0	0	0	$ -
12000	FURNISHINGS	0	0	0	0	0	$ -
13000	SPECIAL CONSTRUCTION	1,039,900	0	0	0	0	$ -
14000	CONVEYING SYSTEMS	0	39,200	0	0	0	$ -
21000	FIRE	51,078	5,457	5,061	8,556	6,156	$ 2,094
22000	PLUMBING	280,900	45,500	0	0	15,500	$ 73,000
23000	HVAC	104,800	39,920	16,870	28,520	14,970	$ -
26000	ELECTRICAL	306,360	27,285	25,305	42,780	30,780	$ 10,470
27000	TECHNOLOGY	0	0	0	0	0	$ -
28000	ELECTRONIC SAFETY & SECURITY	0	0	0	0	0	$ -
31000	SITE WORK, EARTHWORK, ASPHALT PAVING, SIDEWALKS	459,564	0	0	0	0	$ -
32000	EXTERIOR IMPROVEMENTS	634,240	0	0	0	0	$ -
33000	SITE UTILITIES	297,600	0	0	0	0	$ -
	SUBTOTAL A: DIRECT HARD COSTS	$ 6,806,281	$ 420,877	$ 291,851	$ 493,396	$ 364,646	$ 166,774
12.50%	GENERAL CONDITIONS	$ 827,554	$ 50,474	$ 35,022	$ 59,208	$ 43,734	$ 22,023
	SUBTOTAL	$ 7,715,837	$ 471,351	$ 326,873	$ 552,604	$ 408,380	$ 211,427
4.00%	O.C. OVERHEAD	$ 308,353	$ 18,844	$ 13,075	$ 22,104	$ 16,327	$ 8,457
	SUBTOTAL	$ 8,023,791	$ 490,195	$ 339,948	$ 574,709	$ 424,707	$ 219,884
6.00%	O.C. PROFIT	$ 481,967	$ 29,396	$ 20,397	$ 34,482	$ 25,470	$ 13,193
	SUBTOTAL	$ 8,314,736	$ 519,591	$ 360,345	$ 609,190	$ 450,177	$ 233,077
1.29%	O.C. P&P BOND	$ 105,840	$ 6,609	$ 4,648	$ 7,859	$ 5,805	$ 3,007
	SUBTOTAL	$ 8,424,599	$ 526,200	$ 364,993	$ 617,049	$ 455,982	$ 236,084
5.00%	ESCALATION (ALLOWANCE)	$ 421,230	$ 26,310	$ 18,250	$ 30,852	$ 22,799	$ 11,804
	SUBTOTAL	8,845,829	552,510	383,243	647,901	478,781	$ 247,888
20.00%	CONTINGENCY	$ 1,844,767	$ 94,218	$ 65,375	$ 110,521	$ 81,656	$ 45,578
	TOTAL PROBABLE CONSTRUCTION COST	$ 10,690,596	$ 646,728	$ 448,618	758,422	560,437	$ 287,465

Scheme B

OPINION OF COST

SCHEDULE OF VALUES							
DIVISION	DESCRIPTION	SCHEME B - BASE	SCHEME B - TIKI BAR	SCHEME B - 2ND FLOOR RESTAURANT / EXT DECK	SCHEME B - 2ND FLOOR OFFICES / MEETING ROOMS / BALCONIES	SCHEME B - TICKETING / LIFEGUARD BUILDING	SCHEME B - CLOCK TOWER / PUBLIC RESTROOMS
		AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT
	SUBTOTAL A - DIRECT/HARD COSTS	$ 8,896,085	$ 420,917	$ 291,831	$ 493,396	$ 384,466	$ 188,774
12.00%	GENERAL CONDITIONS	$ 827,554	$ 50,474	$ 35,020	$ 59,208	$ 41,734	$ 22,653
	SUBTOTAL	$ 7,723,837	$ 471,391	$ 326,873	$ 552,604	$ 426,199	$ 211,427
4.00%	G.C. OVERHEAD	$ 308,953	$ 18,844	$ 13,075	$ 22,104	$ 16,327	$ 8,457
	SUBTOTAL	$ 8,032,791	$ 490,235	$ 339,948	$ 574,708	$ 424,527	$ 219,884
4.00%	G.C. PROFIT	$ 481,367	$ 29,386	$ 20,387	$ 34,482	$ 25,472	$ 13,193
	SUBTOTAL	$ 8,514,728	$ 519,621	$ 360,345	$ 609,190	$ 449,977	$ 233,077
1.20%	G.C. P&P BOND	$ 102,840	$ 6,535	$ 4,648	$ 7,859	$ 5,805	$ 3,007
	SUBTOTAL	$ 8,834,569	$ 526,035	$ 364,993	$ 617,049	$ 455,782	$ 236,084
5.00%	ESCALATION (ALLOWANCE)	$ 431,230	$ 26,302	$ 18,250	$ 30,853	$ 22,789	$ 11,804
	SUBTOTAL	$ 9,265,809	$ 552,337	$ 383,243	$ 647,901	$ 478,571	$ 247,888
20.00%	CONTINGENCY	$ 1,544,797	$ 94,218	$ 65,370	$ 110,521	$ 81,636	$ 46,579
	TOTAL PROBABLE CONSTRUCTION COST	$ 10,800,596	$ 646,559	$ 448,618	$ 758,423	$ 560,207	$ 287,465

Scheme B
OPINION OF COST

Scheme "B"			
		Deduct	**Total**
	Total Cost		**$10,600,596**
	Deductions:		
	Second Floor Offices/ Meeting Room/ Balconies	$758,422	$9,842,174
	Second Floor Restaurant/ Exterior Deck	$448,618	$9,393,556
	Ticketing/ Lifeguard Building	$560,207	$8,833,349
	Tiki Bar Building	$646,550	$8,186,799
	Clock Tower/ Public Restrooms Building	$297,465	**$7,889,334**

Summary

Scheme A
$9.1 Million

Scheme "A"			
		Deduct	**Total**
	Total Cost		**$9,090,632**
	Deductions:		
	Second Floor Deck	$478,626	$8,612,006
	Lifeguard Building	$452,156	$8,159,850
	Meeting Room	$168,511	**$7,991,339**
	Tiki Bar Building	$630,677	$7,360,662
	Clock Tower/ Public Restrooms Building	$297,465	$7,063,197

Scheme B
$10.6 Million

Scheme "B"			
		Deduct	**Total**
	Total Cost		**$10,600,596**
	Deductions:		
	Second Floor Offices/ Meeting Room/ Balconies	$758,422	$9,842,174
	Second Floor Restaurant/ Exterior Deck	$448,618	$9,393,556
	Ticketing/ Lifeguard Building	$560,207	$8,833,349
	Tiki Bar Building	$646,550	$8,186,799
	Clock Tower/ Public Restrooms Building	$297,465	**$7,889,334**

CPZ Architects | KEITH | Aquatic Consulting Engineers

THANK YOU

Bob McCallister
Aquatic Consultant

City of Lake Worth
New Aquatic Facility Report & Request for Proposal (RFP)

Report Prepared by Bob McCallister, Aquatic Consultant
January 2017

Scope of Service

The following plan and report for a completely new aquatic facility is based upon the prior study and report completed by the Aquatic Consultant.

The components from the previous report for aquatic features, buildings and equipment are contained within this report. The water feature layout fits within the current footprint of the 50-meter pool and deck area, but has its own unique and attractive design. There are additional water features included, as the opportunities are greater to build a completely new aquatic facility with the flexibility of designing on a site footprint that is completely cleared.

The report describes all components of the new aquatic facility with a line item budget for design and construction. The description of the new aquatic facility was used to develop a Request For Proposal (RFP) for architect/engineer and pool designer services, also contained in this report.

The business plan from the prior study and report was slightly modified to reflect the new aquatic facility's operational expenses and revenue potential.

The RFP document for architect/engineer and pool designer services are included in this report and may be configured to the City's standard RFP template. A conceptual rendering of the water feature layout is also provided.

Family Water Park, Wave Rider and Lap Pool

The main pool would contain all the water features and a lap pool. The Wave Rider would be a separate pool with its own filtration operation.

The pool would have a Zero Depth Entry (beach like) with at least 12 floor geyser type sprays in the shallowest area and 8 or more interactive above water stations in the 1 to 2 foot depths. Shaded benches in the shallow water area would allow parents to closely supervise their children playing as they enjoy relaxing with their feet in the water. Parents, toddlers, preschoolers and pre-teens would use this area.

The Zero Depth pool area would slope to transition to other pool areas at 3.5-foot depths. Adjacent to would be the 6-lane lap pool with access via the Zero Depth pool and steps. Another transition channel would enter the 300 linear foot Lazy River that also, accesses the Splash Pool for the 2 – 150-foot Water Slides.

There would be banks of deck sprays spritzing into the Lap Pool and Lazy River and water jets to create rapids in the Lazy River generating an exciting ride while floating around the river.

There is a separate "Wave Rider" feature, which would attract patrons of all ages, especially teens.

Pool Deck Features

A "Tiki Hut" type bar with shade structures, tables and chairs would be located on the north side of the site adjacent to the Casino serving as a snack bar with refreshments for the pool deck level patrons.

The pool deck would feature many deck lounges, umbrellas and pavilion shade structures that would serve for family gatherings, birthday parties as well as for daily patronage enjoyment.

A large plexiglas wall on the east side of the deck would provide a view of the Beach and a view from the beach to the Family water park, a great feature for the water park patrons, serving as a tremendous marketing tool. The Wave Rider, Water Slides and Spray Features could be viewed by the beach and water park patrons as they drive into the Parking Lot, as well as from the Beach accesses.

Water Park Entrance, Bathhouse, Offices, Patio Bar/Restaurant

The water park entrance would be at pool deck level in a new a two-story structure multi-purpose building with a half basement on the south side of the site. The building would be approximately 140' x 30' with a total of 10,500 sq. ft. of usable space.

The bathhouse entrance, bathrooms/showers, lifeguard room, pool storage and pool manager office would be located on the first floor level. On the east end of the first level public restrooms separate from the pool operations would serve the beach patrons as the original building did.

The second floor would house a patio bar/restaurant pavilion that would overlook the beach and water park for public use and/or private rentals. Staff offices would also be located on the second (top) level. There would be a staircase access from the pool deck level that would have restricted public use. An elevator at the front entrance would serve the general public wanting to visit the patio/bar. Another gated staircase would give access to the second level for the public.

A half basement on the west side of the bathhouse would house a garage for beach lifeguard equipment, a beach lifeguard room, bathroom and exercise room. The basement would also house the filter room for all of the water park water plant operations.

Construction Budget			
Demolition & Site Work Allowance			$ 200,000
Building Entrance, Bathhouse, Offices & Patio/Bar 10,500 sq. ft. x $185/sq. ft.			$ 1,942,500
Piling type foundation allowance (required)			$ 300,000
Elevator & Staircases to 2nd floor			$ 40,000
Leisure Pool and Lap lanes 12,000 sq. ft. x $170/sq. ft.			$ 2,040,000
2 – 150' Water Slides			$ 350,000
Pool Deck 12,000 sq. ft. x $5/sq. ft.			$ 60,000
185' - 2' Wall and 6' Plexiglas wind shield allowance			$ 30,000
	Base Sub-Total		$ 4,962,500
Non-Construction Cost			
Architect/Engineering and Pool Designer @ 10% of Base Cost		$ 496,250	
FF&E (Furnishings, Fixtures & Equipment) @ 5% of Base Cost		$ 255,921	
Contingency for unforeseen items @ 10% of Base Cost		$ 496,250	
	Sub-Total	$ 767,763	$ 1,248,421
Alternate Option #1 - Double Wave Rider 4,000 sq. ft.			$ 1,100,000
		Total All Inclusive Construction Budget	**$ 7,310,921**

Projected Revenue and Operational Cost

The pool operations currently cost approximately $300,000 annually with total annual revenue of $66,000 from approximately 10,000 annual users, plus $33,000 from swim team rentals. The pool is currently open 29 hours a week with lifeguard supervision. The pool rentals for swim teams are not staffed with City staff lifeguards.

The all-new constructed family water park facility would provide a much better view of the pool from the beach and from the pool to the beach. This alone would give a good potential for increased usage of the facilities for rental functions and drawing swim patrons to the pool.

The family water park would give the City an attractive and exciting family orientated aquatic facility that would become a destination venue for the community and visitors. With this type of aquatic facility the public demand for more operational hours is highly likely and therefore an increase in the operations budget is necessary.

The family water park facility would require additional staffing including: lifeguards and attendants for cashier and concession operations. In addition, the new high technical filters, controllers and water feature pump motors would need to be maintained 7 days a week. The facility would need thorough cleaning daily, continually during operational hours.

City of Lake Worth Aquatic Facility
Estimated Operations Budget

Operations Outline
Facility open Tuesday – Sunday year round Average 8 hours per day; Average 12 lifeguards; 4 attendants; 1 – PT Supervisor. ; 1- PT Asst. Supervisor; 1 – Admin. Asst. (40hrs.); 1 – Facility Mgr. (40hrs,); 1 – Pool Operator (40hrs.)

Expenditures:

Staffing – Full Time		
1 Facility Program Mgr. (currently on staff)	35,000	
1 Admin. Asst. (Cashier/Receptionist)	26,250	
1 Pool Operator/ Mt. Worker	32,500	
Benefits & FICA (27%)	34,675	
Subtotal full time staff		128,425
Part Time Staff		
2 PT Supv. @ 1400 hrs. ea. ($12/hr.)	33,600	
2 PT Asst. Supv. @ 1400 hrs. ea. ($11/hr.)	30,800	
35 PT Lifeguards @ 5-29 hr./wk. (9.50/hr.)	250,000	
8 Attendants @ 5-29 hr./wk. $8.50/hr.	24,000	
Conc. Workers (Contract Concession)	na	
FICA (6%)	21,600	
Subtotal part time staff		360,000
Operation Supplies		
Office Supplies	500	
Computer Supplies	375	
Janitorial Supplies	2500	
Recreational Supplies	6,000	
Program Materials and Supplies	1,500	
Uniforms	4,000	
Safety Supplies	1,000	
Chemicals (corrected over budgeted 1st draft)	25,000	
Accountable Equipment	3,000	
General Printing	750	
Repairs/Maintenance (Outside Warranty)	11,250	
Subtotal operation supplies		55,875

Utilities		
Communications (phone, Internet, security)	3,000	
Electric	30,000	
Gas	12,500	
Water/Sewer	6,000	
Subtotal Utilities		51,500
Total Expenditure Budget		**$595,800**

City of Lake Worth Aquatic Facility
Estimated Operations Budget
Revenue Projections

Revenue increase is based upon an average 150 patrons for 300 good weather days @ an average of $6.60. However, with the additional water features, it is reasonable to project 100 days of daily attendance at an average of 300. Note: During Private Rentals and Swim Team Rentals require off-duty City lifeguards that are to be paid by the rental group at $15/hr./lifeguard.

It should be noted that the admissions fees for the full water park operational hours (afternoons) could be higher than the morning operations. Morning operations of swim lessons, exercise classes and lap swimming would require minimum staffing since the water features would be turned off and the lap pool would be the primary swimming area. Charging more for the prime time afternoon session would substantially raise the annual revenue potential.

Admission Fees	(30,000 patrons 200 days)	198,000
Admission Fees	(30,000 patrons 100 days)	198,000
Facility Rental Fees	(100 rental @ $500)	50,000
Swim Team Rental	(25 yard lanes only)	66,000
Instructional Classes	(Swim/Exercise Classes)	50,000
Concessions/Resale	(15% of Gross Sales)	30,000
	Total Revenue	**$592,000**

Revenue:	Fee Levels
General Admission	Adult $7.50 & Youth/Sr. $5
Swim Team Lane Rental	$10.00/25 yard lane/hr.
Recreational Pool Rental	$500/2 hrs.

Expenditure Budget	$595,800
Revenue Budget	$592,000
City Annual Subsidy	$ 3,800

Budget Overview

The operational budget is basically a "break even operation". This model budget is based on similar family water park facilities with similar population support. The additional features in this facility would increase potential in rentals, concession revenue and attendance, which in turn would allow the City's Aquatics Operations to be self-supporting.

Management of these operations would need to be adjusted, such as hours of operation. It is the Aquatic Consultant's recommendation to have programs such as swim lessons, exercise classes and lap swimming scheduled during morning hours through the noon hour. In the afternoons, the facility opens for public open swim hours with all the water park features in operation. Staffing for this type of facility requires approximately 20 lifeguards and attendants for each afternoon shift during the peak attendance months.

Budget and Marketing Note

Currently, the City of Lake Worth's beach has an annual attendance of 700,000. The budget revenue projections are very conservative in this report. With the opening up of the beach view from the water park and view of the water park from the beach, the attendance at the water park would increase substantially with revenues would increasing accordingly. It is the projection of the Aquatic Consultant that the proposed improvements would in fact result in revenues exceeding the expenditures during the first year of operations.

Executive Summary

It is the recommendation of the Aquatic Consultant to close the facility due to the number of extensive repairs needed and the potential for the public and/or staff being exposed to hazardous conditions throughout the facility. The cost of repairs and improvements to the existing pool, bathhouse and filter room are estimated to be $2.8 million. Furthermore, the repairs and improvements may not resolve all the issues with what would remain of the original pool.

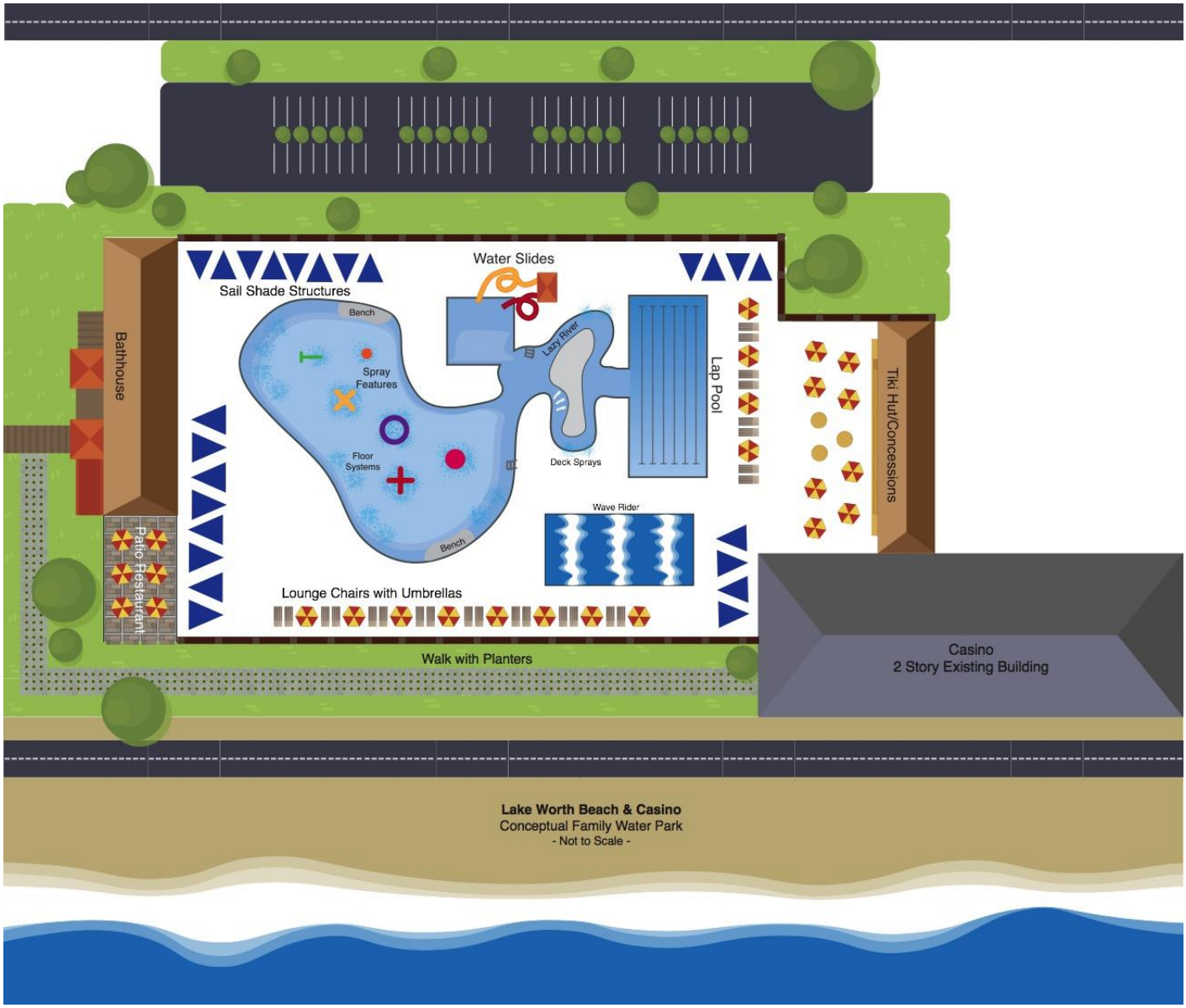
Therefore, it is recommended that the current facility be demolished and an all-new family water park be built in its place. The estimated cost of the new facility is approximately $7.3 million. This facility would able to generate enough revenue to offset all annual operational costs. The new family water park would attract tens of thousands of patrons annually which in turn would provide for a positive economic impact to the City through its local businesses.

In continuation of the Master Plan for the Casino and Beach Facilities Improvements and with the increased patronage resulting from this proposed project, the City should consider additional parking of 200 to 300 spaces. These additional parking spaces would also generate revenue for the City.

-Continue to Exhibits-

“Exhibit A”

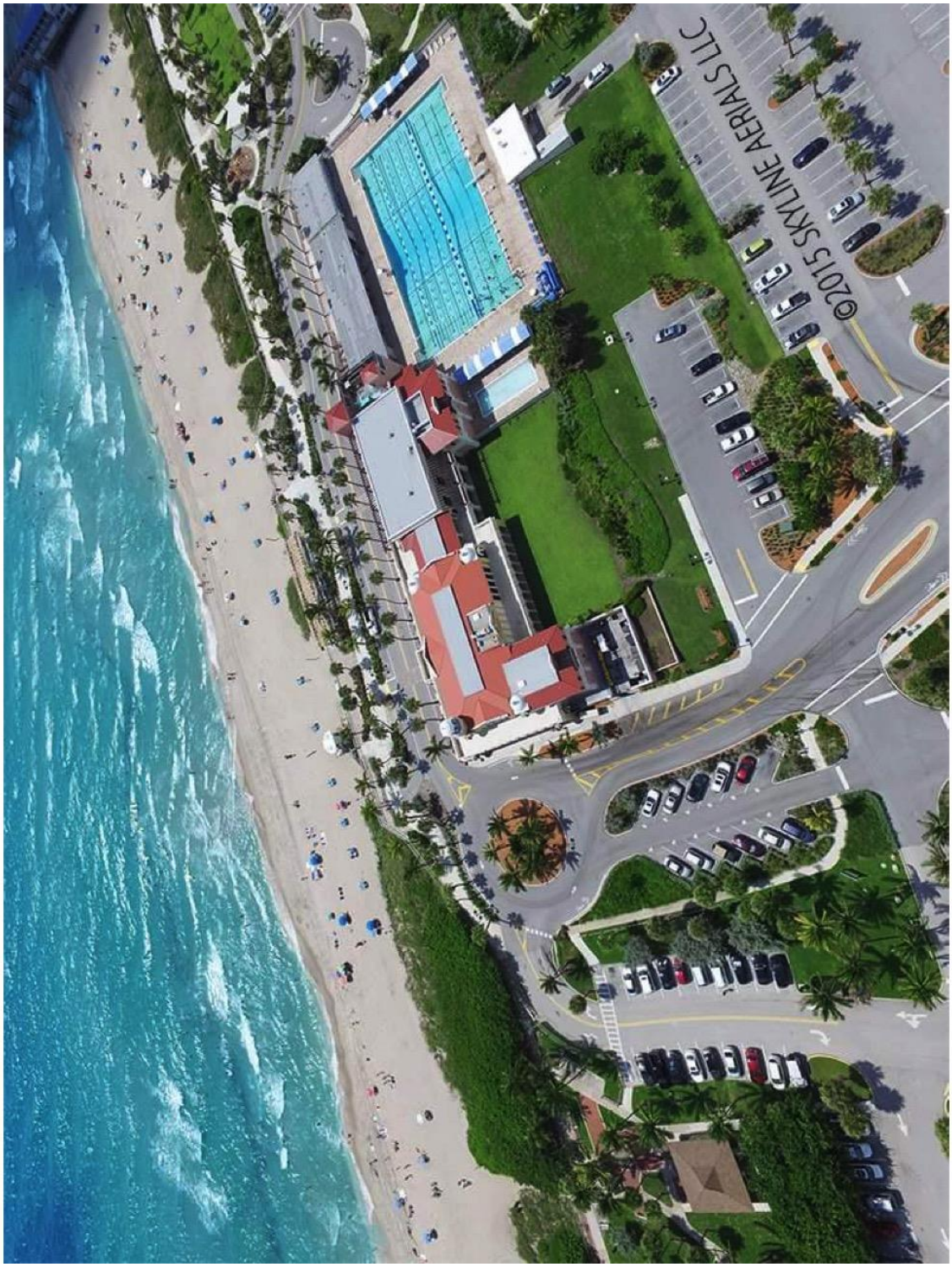
Lake Worth Beach & Casino family water park
Conceptual Rendering
-Not to Scale-



“Exhibit B”

Existing Site 50-Meter Pool Facility Footprint

Ariel Photo of Existing Site
Lake Worth Beach Casino and Pool



"Exhibit C"
Photos of Similar Projects

Seven Springs Water park - Powder Springs GA

Duncan Park Pool and Splash Pad – Fairburn GA

Cumming Aquatic Center – Cumming GA

CITY OF LAKE WORTH,
AQUATICS AND BEACH COMPLEX

Property Condition Assessment

May 9, 2017

Kimley»Horn

Kimley»Horn

May 9, 2017

Mr. Michael Bornstein
Office of the City Manager
City of Lake Worth
7 North Dixie Highway
Lake Worth, FL 33411

RE: ***Aquatics and Beach Complex Baseline Property Condition Assessment***
KH Job #140335001

Dear Mr. Bornstein,

In accordance with our agreement dated July 1, 2014 and Task Order dated April 10, 2017, Kimley-Horn and Associates, Inc. ("Kimley-Horn") has performed a baseline property condition assessment of the Lake Worth Casino Pool and the adjacent facilities. The attached report and exhibits are submitted for you use.

The opinions and conclusions expressed in this report are based on a review of the noted material, as well as my education, training, and experience as a licensed professional engineer. These opinions and conclusions are based on the information currently available to me and may be amended or supplemented should new information become available. This report has been prepared in accordance with the applicable professional standard of care. No other warranties or guarantees, expressed or implied, are made or intended. This report has been prepared solely for the City of Lake Worth for the purposes stated herein and should not be relied upon by any other party or for any other purpose.

Please contact me at (561) 840-0854 or david.stewart@kimley-horn.com should you have any questions.

Sincerely,

Kimley-Horn and Associates, Inc.
CA00000696

David W. Stewart, P.E.
Florida 31180

DAVID WILLIAM STEWART LICENSE No. 31180 STATE OF FLORIDA PROFESSIONAL ENGINEER
Stewart, David
May 10 2017 1:34 AM

Angelina Fairchild, P.E.
Florida 43958

ATTACHMENTS

Property Condition Report
Photographs 1 to 30
Figure 1-3

Kimley»Horn

1.0 EXECUTIVE SUMMARY

The purpose of this Property Condition Assessment is to observe the physical condition of the Aquatics and Beach Complex. The facilities listed in Table 1 were reviewed for conspicuous deficiencies, deferred maintenance, and compliance with the 2014 Florida Building Code. Emphasis was placed on structural stability. For each deficiency, a remedy is recommended which may include further research or testing. An opinion of probable cost to correct the reported deficiencies and an estimated remaining service life for major building systems are also included.

The Main Lap Pool is a 50-meter, competition style pool constructed in 1971. The pool finish was replaced in 2008. The Pool is generally in good shape structurally with no indication of differential settlement or structural deterioration. Recommended repairs include resurfacing the pool finish, locating and repairing piping leaks and replacing the underwater lighting.

The Wading Pool is a shallow 16 foot by 40 foot pool located north of the Main Lap Pool. It was also constructed in 1971 and shares the pool filtration and heating systems of the Main Pool. The Wading Pool is generally in good shape structurally. It is recommended that temperatures be monitored while the pool heaters are in use to prevent an unsafe condition.

The Pool Deck, constructed in 1971 was reconstructed in 2008, with brick pavers. The Pool Deck finish is generally in good condition. It is recommended that blocked area drains be cleared to avoid creating a potential slipping hazard.

The Bathhouse and Offices located east of the Main Lap Pool were constructed in two phases. In 1971 the Pool Restrooms were constructed including a Pool Office and Lifeguard Room. The Beach Restrooms were added later. Recommended repairs include roof replacement, lighting, plumbing, ventilation, ADA accessibility; and window and door hurricane protection.

The Pool Filtration Equipment Building was constructed in 1971 and later modified by the addition of a Chlorine Storage Building. In 2008, new pool heaters and water filters were installed. The concrete roof is structurally damaged and replacement is recommended. The original piping is at the end of its expected service life. It is recommended that the pool drain and filtered water return lines within the building be replaced.

Table 1 – Opinion of Probable Cost to Correct Observed Deficiencies

Facility	OPC
Main Lap Pool	$93,100
Wading Pool	$2,800
Pool Deck	$46,600
Pool Restrooms	$113,900
Beach Restrooms	$5,500
Pool Filter Equipment Building	$138,500
Chlorine Storage Building	$1,600
Total	$402,000

2.0 PURPOSE AND SCOPE

The City of Lake Worth has directed Kimley-Horn and Associates, Inc. ("Kimley-Horn") to perform a baseline property condition assessment (PCA) for facilities at the Aquatics and Beach Complex in general conformance with ASTM E2018-15. The purpose of the PCA is to observe and report, to the extent feasible, on the physical condition of the pools, building and improvements listed below.

1. Main Lap Pool: 50-meter pool, drain and return piping
2. Wading Pool: Pool, drain and return piping
3. Pool Deck: Flat work, surface drains
4. Bathhouse and Offices: Pool Restrooms, Beach Restrooms, Pool Office, Lifeguard Room, Utility Spaces
5. Pool Filter Equipment Building: Pump Filter Room, Electrical Room, Chlorine Storage

The purpose of the PCA is to observe and report, to the extent feasible, on the physical condition of the subject building and improvements. As a part of this assessment, David Stewart, P.E, and Hanniah Rodríguez, E.I., made a site visit on April 17, 2017, interviewed City staff and reviewed available construction documents.

The systems and building elements listed below were reviewed for conspicuous deficiencies, material deferred maintenance, and compliance with the 2014 Florida Building Code. Emphasis was placed on the structural stability of the facilities. Site work and other detached structures beyond the limits of the facilities listed above were specifically excluded from the scope of this PCA.

1. Structural Frame and Building Envelope
2. Roofing
3. Life Safety/Fire Protection
4. Interior Elements
5. ADA Requirements
6. Special Exterior Architectural Finishes
7. Mechanical, Electrical, Plumbing and Pool Filtration Systems: Apparent condition only; systems were not operated or performance tested at this time

This report includes descriptions of systems and components and their general physical condition. For each material physical deficiency, Kimley-Horn has suggested a remedy which may include further research or testing, if appropriate. Kimley-Horn prepared an engineer's opinion of probable cost to correct the reported deficiencies. Estimates of useful life remaining for major building systems (i.e. roofing, foundation, etc.) are also included in this PCA report.

3.0 DOCUMENT REVIEW AND INTERVIEWS

The following documents were provided to Kimley-Horn for review prior to our site inspection:

- Pool Facilities Building for City of Lake Worth drawings prepared by Adair & Brady, Inc.
- Aquatics and Beach Complex improvements by Aquatic Consultant, Bob McCallister, LLC
- Construction photographs from 1971

The following documents were provided to Kimley-Horn after our site inspection:

- Lake Worth pool renovation as-builts; 2008 by Sinclair Engineering Company
- Technical Specifications, dated March 2008 by Stanley Consultants, Inc.
- Before and after photographs of 2008 renovations for Lake Worth Municipal Pool

Interview with Aquatics Manager, Leisure Services (Doug Yoakum), April 17, 2017:

- The Main Pool was resurfaced in 2008.
- The water line in the Main Pool is not uniform relative to the perimeter gutter. The east gutter is several inches below the west gutter.
- The Main Pool is losing approximately 2 inches of water per day when the water line is at normal levels. If not replaced, the water level drops to approximately the top of the lane marker tiles and then slows to a rate similar to pan evaporation. Make-up water is costing approximately $3,500 per month.
- Water chemistry in the Main Pool is difficult to balance due to the large volume of fresh water added each day.
- Piping repairs in the Pool Equipment Building included relining some piping that affected the accuracy of the flow meters.
- Soil accumulates on the floor in the northeast corner of the Pool Equipment Building.
- The variable frequency drives on the pool filtration pumps do not work; they have been bypassed.
- The main pool heaters were replaced in 2016. The Wading Pool is heated by the same equipment as the Main Pool. In the winter, the Wading Pool becomes too hot and must be closed.
- Ceiling spalls have occurred in the Filtration Room and the Electrical Room, causing the pool to be closed in February 2017.
- Water leaks from within electrical conduits entering the east wall of the Pool Equipment Room.
- Bottom sediments in the Main Pool do not collect uniformly around the four main drains. The two east drains may have a flow restriction.
- The east deck area drains are plugged with hard debris and are not functional. Efforts to free the drains and associated piping were not successful.
- The northeast corner of the pool deck was undermined by an opening in the gutter drain piping. Repairs were made in 2016.
- The northwest corner of the pool deck was undermined approximately 5 years ago and caused a break in the piping serving the Wading Pool.

Interview with Casino Beach Complex Facility Manager (Phil Johnson), April 17, 2017:

- The cause of the northwest pool deck undermining was the incomplete installation of an area deck drain.
- The 1-inch domestic water line serving the Beach Restrooms was replaced with a 2-inch diameter line to correct water pressure problems.
- The roof edge (fascia and soffit) of the pool bathrooms was repaired on three occasions. The sheet metal fascia was installed for the sake of appearance.

4.0 SYSTEM DESCRIPTIONS AND OBSERVATIONS

4.1 General

The existing pool facilities located at the City of Lake Worth were designed in 1971 and consist of a 50-meter Olympic swimming pool, a wading pool, and three buildings: the Bathhouse and Offices Building, The Pool Filter Equipment Building, and the Chlorine Storage Building (See Figure 1). Both pools are currently empty and are not open to the public. Renovations to the 50-meter Olympic Swimming Pool were designed in 2008 by Sinclair Engineering Company. The Bathhouse and Offices Building has an addition on the South side of the building that was not part of the original construction in 1971. The South addition includes both men's and women's beachside bathrooms.

Access to the site was provided and facilitated by City staff. Readily accessible areas were visually reviewed and compared with the latest construction documents available. The interior of all rooms and representative portions of the building exterior were reviewed for conspicuous deficiencies, material differed maintenance and compliance with the 2014 Florida Building Code. Our noted observations are presented in this section.

4.2 Main Lap Pool

The Main Lap Pool is a 50-meter, competition style pool constructed in 1971 (Photo 1). It replaced a similar pool that was part of the original Lake Worth Casino built in 1920. The current pool was constructed with a reinforced concrete shell on compacted sand subgrade. The depth varies from approximately 3.5 ft at the north and south ends, to approximately 12 feet at the center. Lane striping facilitates lap swimming in either the 50-meter or the 23 -meter direction.

The pool finish below the waterline is Portland cement plaster, similar to Marcite, that was replaced in 2008. The perimeter gutter and the stairs are covered with a resin bonded aggregate finish. The reinforced concrete shell cannot be directly viewed since it is concealed by finishes and the surrounding pool deck. The rigid pool finish will generally reflect cracks in the underlying shell.

The Main Lap Pool is generally in good shape structurally with no indication of differential settlement or structural deterioration.

The pool filtration system drains by gravity to the equipment building. Clean water is pumped back to the pool and distributed around the perimeter (See Figure 2).

Observations and Recommendations:

- The pool finish is debonded over approximately 30% of the floor and wall area. This was determined by sounding the finish and noting acoustical anomalies. Most of the defects were observed in patches and not large strips, and no cracks were observed in the finish below the gutter (Photo 2). Cracks were observed on the tiles at the water line and near the joints on the pool curb. Cracks with mineral stains were present in the gutter finish and on the top tread of the pool stairs (Photo 3). These areas were also sounded and acoustical anomalies indicate much of the gutter finish has debonded. **Recommendation: Refinish the pool, including the gutters, up to the precast concrete coping.**
- It was reported that, when the pool is full, water is lost at a rate of approximately 2 inches per day. When the water level reaches 16 inches below the gutter line, losses reduce to approximately evaporative losses. The water loss indicates a break or breaks in the return water piping (See Figure 3). **Recommendation: Remove the pool deck at the four corners of the pool and at the main lines to the Filter Building to expose the return water distribution piping. Isolate and pressure test each piping leg to determine the approximate location of the leak. Inspect the pipe interior for joint separation, breaks or other defects.**
- Water leaks into the housing of the underwater lights (Photo 4). Mounting screws are missing. It is reported that water leaks through the electrical conduit into the Pool Filter Building. **Recommendation: Replace the underwater lights.**

4.3 Wading Pool

The Wading Pool is a shallow 16 foot by 40 foot pool located north of the Main Lap Pool. It was also constructed in 1971 and shares the pool filtration system of the Main Pool. The Wading Pool is generally in good shape structurally with no indication of differential settlement or structural deterioration.

Observations and Recommendations:

- The Wading Pool is heated by the same equipment as the Main Pool. It was reported, that in the winter, the Wading Pool becomes too hot and must be closed. **Recommendation: Monitor Wading Pool temperatures to prevent unsafe conditions. Consider options to regulate heated water flow or provide an independent heater.**

4.4 Pool Deck

The Pool Deck surrounding the Main and Wading Pools was originally constructed in 1971. In 2008, it was reconstructed with new brick pavers and deck area drains. The Pool Deck finish is generally in good condition (Photo 5).

Observations and Recommendations:

- Reportedly, the area drains on the east side of the pool are filled with hard debris and cannot be cleared (Photo 6). Lack of drainage creates a potential slipping hazard. **Recommendation: Remove the pool deck to expose the deck drainage piping. Replace the piping and verify clear flow to the storm drain. Inspect with a plumber's camera all deck drain lines for blockage, separated joints or other defects.**

4.5 Bathhouse and Offices

The bathhouse and offices located east of the Main Lap Pool were constructed in two phases. In 1971 the northern portion was constructed coincident with the pools. The pool restrooms include separate women's and men's toilets, shower and changing areas. A concessions office and Lifeguard Room are also in this original building. The southern portion was constructed before 1995 to serve beach goers. The Beach Restrooms include women's and men's toilets, shower and changing areas.

Both buildings have similar structural frames. The roof is constructed with precast, prestressed hollow core concrete slabs. The roof covering is a modified bitumen built-up roof of undetermined age. The bearing walls are concrete masonry supported by a reinforced concrete monolithic floor slab. Walls are reinforced with tie-columns and tie-beams.

Observations and Recommendations for the Pool Restrooms:

- The roof covering is near the end of its service life. Evidence of old leaks were observed on both bathrooms' roofs. Mineral deposits hang from the roof joints in both men's and women's bathrooms (Photo 7). No active leaks were observed. The roof covering is worn, and has been damaged by UV exposure. Protective mineral granules have been lost due to wear and foot traffic (Photo 8). The roof is patched at several locations one area is approximately 9 feet. by 12 feet (Photo 9). The building expansion joint does not continue to the roofs perimeter. Attachment of exterior light fixtures was done with through-bolts penetrating the roof without sealant. **Recommendation: Replace the roof covering with a modified bitumen built-up roof. Seal through bolt penetrations.**
- The restrooms are ventilated, but lack air conditioning. The exterior walls are not insulated. The roof is minimally insulated, but does not meet current FBC requirements. **Recommendation: Install board insulation on the roof to meet current FBC requirements.**
- Handicapped stalls do not comply with dimension standards of the Florida Accessibility Code, Section 604.3.1. The stall is not a minimum of 60 inches measured perpendicular from the side wall and 56 inches minimum measured perpendicular from the rear wall. The handicapped stall dimensions on both men's and women's bathroom on the Bathhouse and Offices Building that serve the pool were observed to be less than the required minimum dimensions. Lavatory drains lack insulation (Photo 10). **Recommendation: Reconstruct ADA stalls to meet FAC requirements.**
- The number of bathroom stalls did not match the existing plans from 1971 for both men's and women's bathrooms. **Recommendation: Verify the number of fixtures based on the projected occupancy of the pool.**
- The lighting in both men's and women's bathrooms was poor with maximun lighting levels below 10 foot-candles using both natural and artificial lighting. Minimum levels below 0.2 foot-candles were measured in some toilet stalls. **Recommendation: Redesign and replace the interior lighting to meet current FBC requirements of 10 foot-candles (average).**
- A 3-1/2 inch high raised curb separates the shower area from the dressing room in the men's bathroom. This creates a tripping hazard and prevents ADA access to the shower room (Photo 11). **Recommendation: Remove the concrete curb at the men's shower room. Slope the floor to drains.**

- In the women's restroom, a concrete masonry partition was modified to create a space for a towel dispenser. Steel reinforcement was cut (Photo12). **Recommendation: Repair damaged concrete masonry.**
- The Lifeguard Room bathroom lacks a mechanical ventilator as required by FBC. The light fixture lacks a diffuser (Photo 13). **Recommendation: Replace missing or damaged mechanical, electrical and plumbing equipment.**
- The Pool Office air conditioner is positioned to discharge waste heat into the corridor, which is the public entry to the pool facility (Photo 14). **Recommendation: Replace the air conditioner with a roof-mounted split system.**
- The Pool Office, Lifeguard Room and Manager' Office have exterior windows and door lights that are not impact rated (Photo 15). **Recommendation: Replace windows with impact rated windows with a Florida Product Approval or provide protective covers.**
- The Pool Office floor drain is not flush with the tile surface and creates a tripping hazard (Photo 16). **Recommendation: Raise the drain.**

Observations and Recommendations for the Beach Restrooms:

- The mechanical space between the men's and women's toilets is poorly ventilated. **Recommendation: Install mechanical ventilation (Photo 17).**
- The mechanical space floor drain has been plugged. It was reported that sanitary waste backflows out of the floor drain (Photo18). **Recommendation: Inspect sanitary drain lines and building sewer. Clear any blockage.**
- Drain, waste, land vent piping is poorly supported. Threaded rod hangers are loaded in bending instead of tension. Brackets are severely corroded (Photo 19). **Recommendation: Replace pipe supports.**
- The lavatory drain in the ADA stalls is not insulated. **Recommendation: Replace missing insulation.**
- The floor drain in the women's restroom is too high, causing water to puddle on the floor (Photo 20)**. Recommendation: Lower the floor drain.**

4.6 Pool Filter Equipment Building

The Pool Filtration Equipment Building was constructed in 1971 coincident with the pools. It was modified by the addition of a Chlorine Storage Building. The Pool Equipment Building is located west of the Main Lap Pool and has a finish floor that is approximately 7 feet lower than the pool deck. The roof is a cast-in-place reinforced concrete slab supported on concrete masonry bearing walls. The roof covering is a fluid, applied membrane. The walls are reinforced with tie-beams and tie-columns. The lower portion of the east, south and north walls is below grade.

The pool filtration equipment consists of a circulating pump, two transfer pumps, diatomaceous earth filters, chemical injection pumps and controls. In 2008, new pool heaters and water filters were installed.

Observations and Recommendations:

- The concrete ceiling of the pump room (underside of the roof) has spalled at many locations. A few locations are still exposed, but most have been covered with half inch-thick plywood to protect personnel from falling debris (Photo 21). Approximately 30% of the area of the ceiling was observed to be covered, which meets the Florida Building Code definition of substantial significant structural damage. Exposed reinforcing steel was observed on the roof from the outside, and throughout the building from in the inside (Photo 22). **Recommendation: Remove the cast-in-place concrete roof structure and replace with precast, prestressed hollow core slabs.**
- Exhaust stacks on the roof are corroded at the base flange, allowing water intrusion into the building (Photo 23). The roof slab has multiple cracks in the upper surface that have penetrated the roof covering (Photo 24). **Recommendation: Replace the roof covering with a modified bitumen built-up roof over 1-inch insulation board. Replace all sheet metal stacks and flashings.**
- The interior face of one tie-column in the east wall of the pump room has spalled, exposing reinforcing steel (Photo 25). **Recommendation: Clean the corroded steel and apply a patching mortar.**
- Much of the piping is from the original 1971 construction and is at the end of its expected service life of 25 to 45 years. It was reported that numerous repairs have been made to stop leaks, including slip lining some pipe interiors (Photo 26, 27). **Recommendation: Remove the pool deck adjacent to the building and expose the piping serving the Main Pool and the Wading Pool. Replace the pool drain and return lines inside the pump room and a minimum of 5 feet outside the building.**

4.7 Chlorine Storage Building

The Chlorine Storage Building is a one-story, concrete masonry building constructed in 1989. The roof is framed with wood joists supporting plywood sheathing and an asphalt roof covering topped with aluminized paint. The bearing walls are concrete masonry, reinforced with tie-columns and tie-beams.

Observations and Recommendations:

- The roof covering does not meet current building code requirements for built-up roofs. A long-term leak is present near the east edge. Small blisters are present near the south edge (Photo 28). **Recommendation: Replace the roof covering.**
- The roof sheathing near the east edge (adjacent to the Filter Building) is soft and yields under foot pressure. The plywood sheathing is damaged from decay (Photo 29). **Recommendation: Replace damaged roof sheathing. Inspect roof framing and repair if required**.
- Hurricane straps connecting the roof joists to the masonry walls are missing fasteners at many locations (Photo 30). **Recommendation: Install missing fasteners into tie-beam.**

5.0 ADDITIONAL CONSIDERATIONS

5.1 Nominal Capacity of Restroom Roof

An analysis was performed on the capacity of the cantilevered roof section on the east side of the Bathhouse and Offices Building. The nominal capacity of the hollow core concrete roof slab was compared with the worst case expected uplift pressure. The hollow core slab appears to have adequate strength to resist current design wind pressures. Only 93% of its nominal capacity is used.

Table 2 – Capacity of Cantilevered Wall Section of Bathhouse and Offices Building

Maximum Roof Uplift (psf)	Slab DL (psf)	Slab LL (psf)	Utilization
61.2	46*	20	0.93

*Source: PCI Design Handbook Second Edition – Figure 2.4.1

5.2 Remaining Service Life

Design criteria for new public facilities includes consideration of the service life for the structures and major building systems. Kimley-Horn compared the age of the subject pools and facilities with service life criteria from the Department of Veterans Affairs, the Federal Green Construction Guide for Specifiers and the Public Service Commission rules for water and wastewater utilities. Except for the structural framing and foundations, all the major building systems have already exceeded what is considered a normal design service life. Some systems can continue to be repaired and maintained to keep them in service, but others are recommended for replacement at this time. The remaining service life (RSL) estimated in Table 3 assumes the recommended repairs are completed in a timely fashion. Systems with a RSL of zero cannot be repaired and are recommended for replacement.

Table 3 – Estimated Remaining Useful Service Life in Years

Facility	Structure	Roof	MEP	Interior Elements	Exterior Finishes
Main Lap Pool	20	---	Return Piping 0 Drain, Gutter Piping 10 Under Water Lighting 0-3	---	1-3
Wading Pool	20	---	10	---	5
Pool Deck	10	---	East Drains 0 Other Drains 10	---	10
Pool Restrooms	10	0-3	Electrical 0 Plumbing 0-5 Fixtures 0-5	Partitions 0 Finishes 0	10
Beach Restrooms	20	5	Electrical 10 Plumbing 20 Fixtures 5-10	Partitions 10 Finishes 10	10
Pool Equipment	Roof 0 Walls 10 Foundation 10	0	Piping 0-5 Pumps, Filters, Chemical Feed 3-5	0-5	10
Chlorine Storage	10	0	5	---	10

6.0 OPINION OF PROBABLE COST

Kimley-Horn prepared an engineer's opinion of probable cost ("OPC") to correct the reported deficiencies. The OPC costs shown in Table 1 below should only be construed as preliminary budgets. Actual costs can vary from the consultant's opinions of probable costs depending on such matters as type and design of suggested remedy, quality of materials and installation, manufacturer and type of equipment or system selected, field conditions, whether a physical deficiency is repaired or replaced in whole, phasing of the work, quality of contractor, quality of project management exercised, market conditions, whether competitive pricing is solicited, timeframe between the issuance of the opinion and the actual work being performed, etc.

Table 1 (repeated) – Opinion of Probable Cost to Correct Observed Deficiencies

Facility	OPC*
Main Lap Pool	$93,100
Wading Pool	$2,800
Pool Deck	$46,600
Pool Restrooms	$113,900
Beach Restrooms	$5,500
Pool Filter Equipment Building	$138,500
Chlorine Storage Building	$1,600
Total	$402,000

*Includes: 25% scope contingency for concealed conditions; 5% for bonds, insurance, permits; and 12% for design and construction engineering.

7.0 OUT OF SCOPE CONSIDERATIONS

Assessment of the functional layout of the aquatic center including the size, shape and depth of the main pool is beyond the scope of this assessment. Kimley-Horn's recommendations are intended to maintain or restore existing improvements to a useable condition based on the original design.

The location of the Aquatics and Beach Complex seaward of the Coastal Construction Control Line may affect the scope of repairs or modifications that may be permitted. Permitting through the Florida Department of Environmental Protection will be required.

Review of current FEMA Flood maps and other public source flood hazard information was not performed. The existing building floor elevations have not been compared with flood zones affecting this site.

Kimley»Horn
1920 Wekiva Way, Suite 200
West Palm Beach, Florida 33411

Aquatics and Beach Complex Property Condition Assessment

Photograph Sheet

KHA Job No.: 140335001
KHA Rep.: David Stewart, P.E.
Date: May 9, 2017.

Photo No. 1

Remarks: 50-meter competition style pool constructed in 1971.

Location: Main Lap Pool

Photo No. 2

Remarks: Delaminated pool patches. No cracks observed in the finish below the gutter.

Location: Main Lap Pool

Photo No. 3

Remarks: Cracks with mineral stains on top tread of the pool stairs.

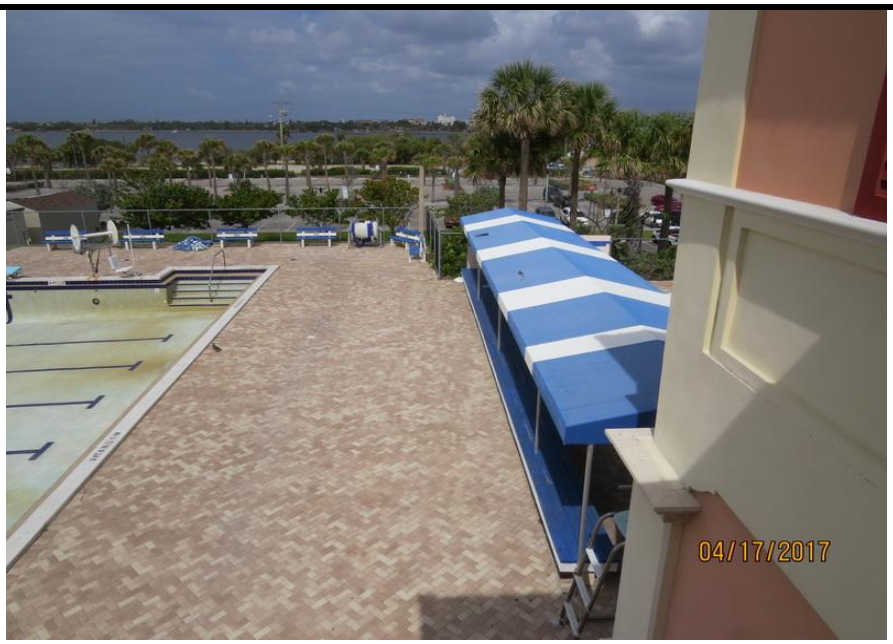
Location: Main Lap Pool

Photo No. 4

Remarks: Water leaks into the housing of the underwater lights.

Location: Main Lap Pool

Photo No. 5



Remarks: Pool deck finish is generally in good condition.

Location: Main Lap Pool

Photo No. 6

Remarks: Area drains on East side of pool are filled with hard debris.

Location: Main Lap Pool

Photo No. 7

Remarks: Mineral Deposits hang from roof joints on men's and women's bathrooms.

Location: Pool Restrooms

Photo No. 8

Remarks: Protective mineral granules on roof have been lost due to wear and foot traffic.

Location: Pool Restrooms

Photo No. 9

Remarks: 9ft x 12ft roof patch.

Location: Pool Restrooms

Photo No. 10

Remarks: Handicapped stall dimension are less than the required. Lavatory drains lack insulation.

Location: Pool Restrooms

Photo No. 11

Remarks: Tripping hazard preventing ADA access to men's shower room.

Location: Pool Restrooms

Photo No. 12

Remarks: Steel reinforcement was cut on masonry partition on women's bathroom.

Location: Pool Restrooms

Photo No. 13

Remarks: Life Guard room bathroom lacks mechanical ventilator per FBC. The light fixture lacks a diffuser.

Location: Pool Restrooms

Photo No. 14

Remarks: Pool Office air conditioner is positioned to discharge waste heat into the public entry corridor.

Location: Pool Restrooms

Kimley»Horn
1920 Wekiva Way, Suite 200
West Palm Beach, Florida 33411

Aquatics and Beach Complex
Property Condition Assessment
Photograph Sheet

KHA Job No.: 140335001
KHA Rep.: David Stewart, P.E.
Date: May 9, 2017.

Photo No. 15

Remarks: Non-impact rated windows and door lites on the Pool Office, Life Guard room and Manager Office.

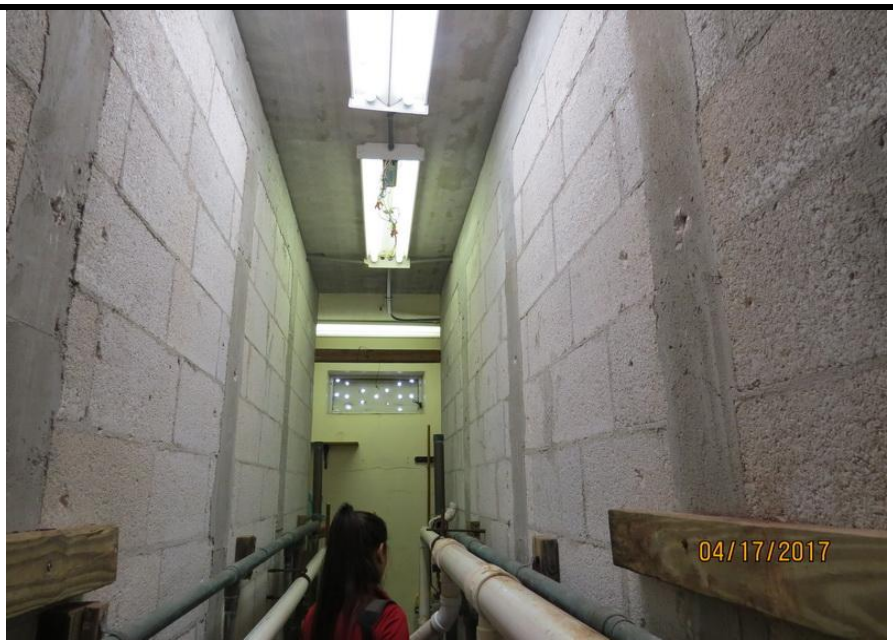
Location: Pool Restrooms

Photo No. 16

Remarks: Pool drain on the Pool Office floor is not flush with the tile surface and creates a tripping hazard.

Location: Pool Restrooms

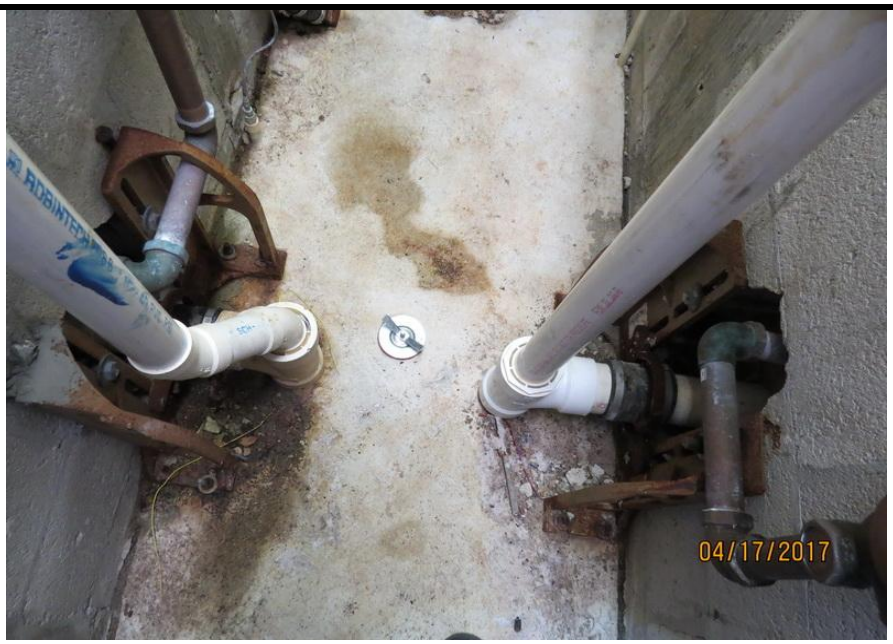
Photo No. 17



Remarks: Mechanical space between men's and women's toilets is poorly ventilated.

Location: Beach Restrooms

Photo No. 18



Remarks: Mechanical space floor drain has been plugged.

Location: Beach Restrooms

Photo No. 19

Remarks: Drain, waste, vent piping is poorly supported. Brackets are severely corroded.

Location: Beach Restrooms

Photo No. 20

Remarks: Floor drain on women's restroom is too high causing water to puddle on the floor.

Location: Beach Restrooms

Photo No. 21

Remarks: Spalling at many roof locations mostly covered by half inch-thick plywood.

Location: Pool Filter Equipment Building

Photo No. 22

Remarks: Exposed reinforcing steel.

Location: Pool Filter Equipment Building

Photo No. 23

Remarks: Exhaust stacks on the roof are corroded at the base flange allowing water intrusion into the building.

Location: Pool Filter Equipment Building

Photo No. 24

Remarks: Roof slab has multiple cracks in the upper surface that have penetrated the roof covering.

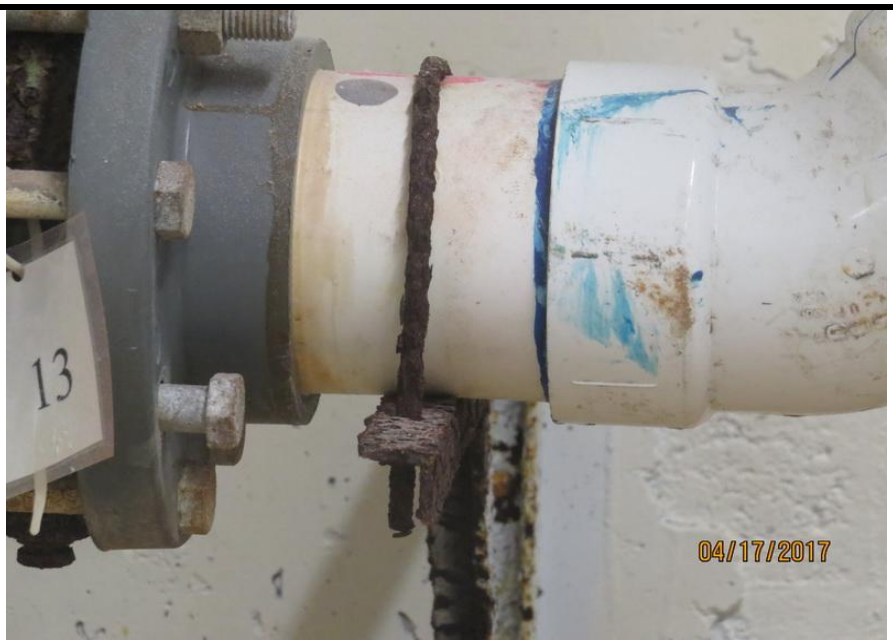
Location: Pool Filter Equipment Building

Photo No. 25

Remarks: Exposed reinforcing steel at interior face of one tie-column in the east wall of the pump room.

Location: Pool Filter Equipment Building

Photo No. 26



Remarks: Numerous repairs have been made to stop leaks including slip lining some pipe interiors.

Location: Pool Filter Equipment Building

Photo No. 27

Remarks: Numerous repairs have been made to stop leaks including slip lining some pipe interiors.

Location: Pool Filter Equipment Building

Photo No. 28

Remarks: Small blisters on waterproofing are present near the south edge of the roof.

Location: Chlorine Storage Building

Photo No. 29

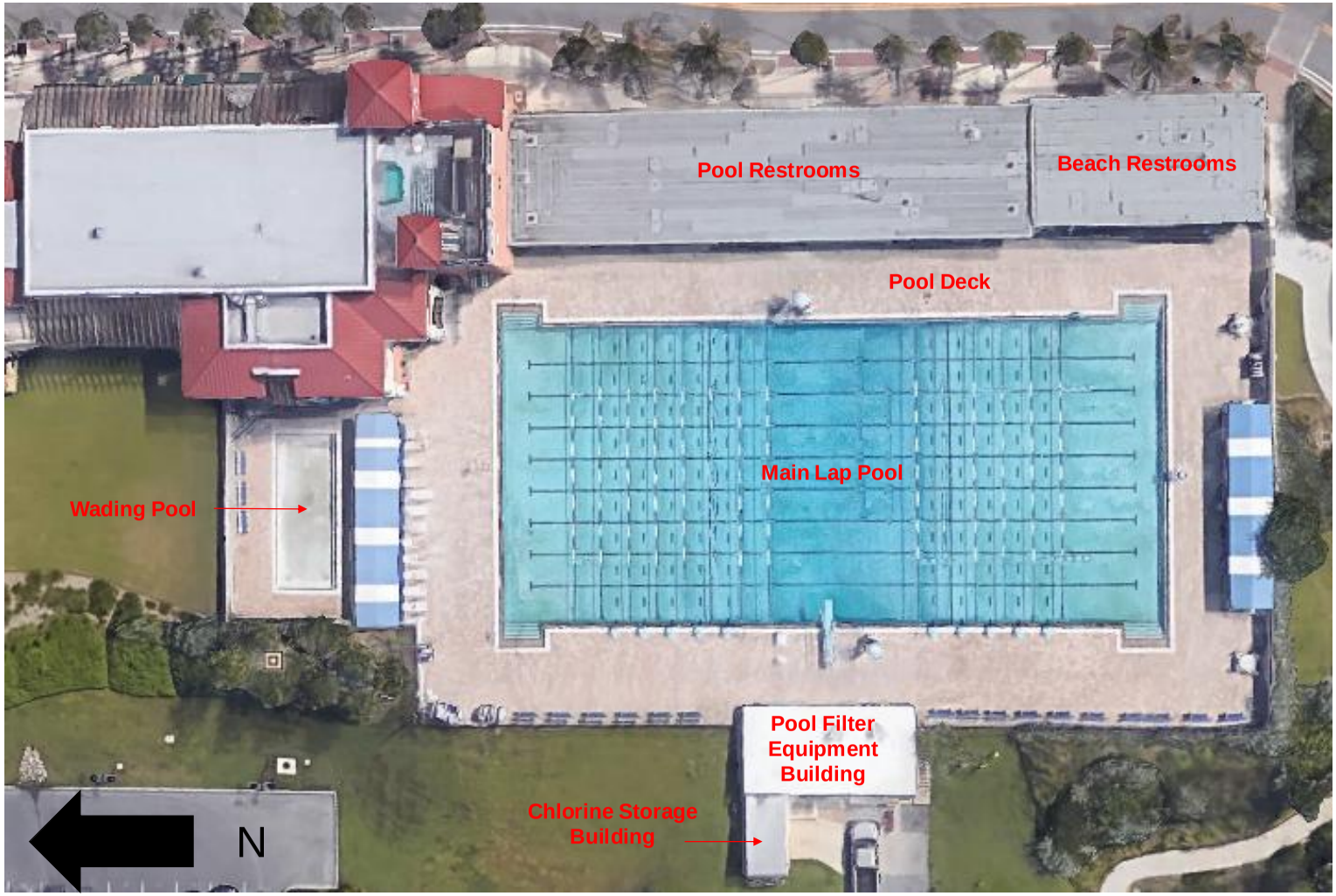
Remarks: The roof sheathing near the east edge is soft and yields under foot pressure.

Location: Chlorine Storage Building

Photo No. 30

Remarks: Hurricane straps connecting the roof joists to the masonry walls are missing fasteners.

Location: Chlorine Storage Building



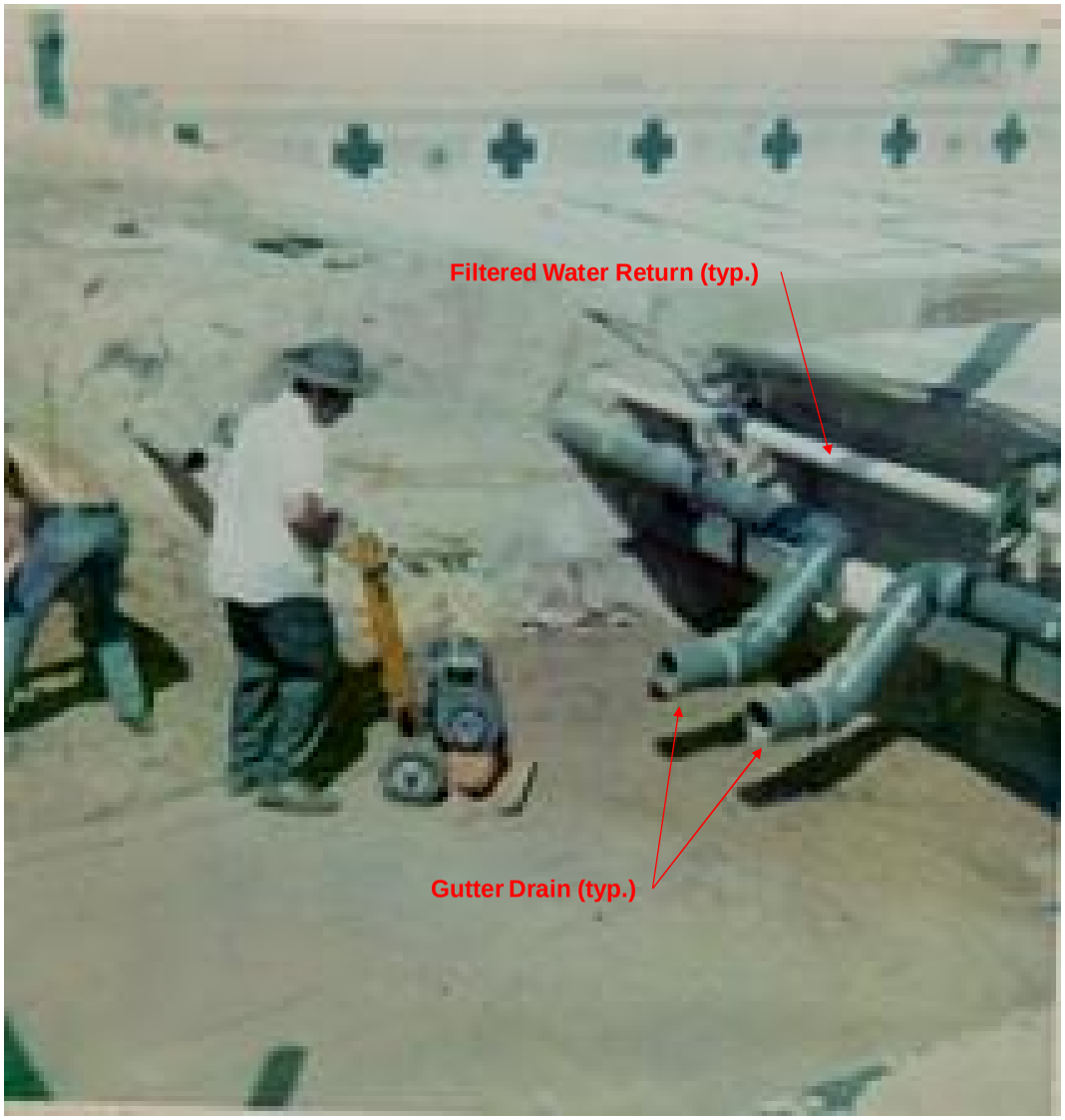
Kimley»Horn

Figure 1 – Aerial View

Source: 1971 Construction Photos

Kimley»Horn

Figure 2 – Gutter Drain and Filtered Water Return at West of Main Lap Pool



Source: 1971 Construction Photos

Kimley»Horn

Figure 3 – Gutter Drain and Filtered Water Return Between Filter Building and Main Lap Pool

CITY OF LAKE WORTH,
AQUATICS AND BEACH COMPLEX

Supplement to Property Condition Assessment

May 16, 2017

Kimley»Horn

Kimley»Horn

May 16, 2017

Mr. Michael Bornstein
Office of the City Manager
City of Lake Worth
7 North Dixie Highway
Lake Worth, FL 33411

RE: ***Supplement to Aquatics and Beach Complex Baseline Property Condition Assessment***
KH Job #140335001

Dear Mr. Bornstein,

The following is a Supplement to the City of Lake Worth, Aquatics and Beach Complex Property Condition Assessment Report by Kimley-Horn dated May 9, 2017.

The Supplement is in response to the following additional information and requests:

1. Request to provide additional backup to Table 1 - Opinion of Probable Cost (OPC) included in the PCA report.
2. Review of Additional information received from the City on May 12, 2017: *Inspection of Lake Worth Casino Pool Report by Sinclair Engineering Company dated July 9, 2012.*
3. Request to expand the discussion on the out of Scope considerations.

The opinions and conclusions expressed in this report are based on a view of the noted material, as well as my education, training, and experience as a licensed professional engineer. These opinions and conclusions are based on the information currently available to me and may be amended or supplemented should new information become available. This report has been prepared in accordance with the applicable professional standard of care. No other warranties or guarantees, expressed or implied, are made or intended. This report has been prepared solely for the City of Lake Worth for the purposes stated herein and should not be relied upon by any other party or for any other purpose.

Please contact me at (561) 840-0854 or david.stewart@kimley-horn.com should you have any questions.

Sincerely,

Kimley-Horn and Associates, Inc.
CA00000696

David W. Stewart, P.E.
Florida 31180

Angelina Fairchild, P.E.
Florida 43958

Kimley»Horn

SUPPLEMENT TO PCA REPORT ISSUED ON MAY 9, 2017

Expanded OPC Table

The Aquatics and Beach Complex Property Condition Assessment Report by Kimley-Horn dated May 9, 2017 (PCA) includes a summary table of the Opinion of Probable Cost to Correct Observed Deficiencies (OPC). An expanded version of this table, including estimated quantities, unit prices, contingencies, and other considerations used to develop the OPC is attached as Appendix A. Adjustment of unit prices to more closely follow RS Means Cost Data for Commercial Reconstruction projects and additional surface preparation when refinishing the Main Lap Pool increased the OPC in several areas. A revised Table 1 is provided below.

Table 1 – Opinion of Probable Cost to Correct Observed Deficiencies

Facility	OPC
Main Lap Pool	$186,400*
Wading Pool	$2,800
Pool Deck	$46,600
Pool Restrooms	$125,000*
Beach Restrooms	$5,500
Pool Filter Equipment Building	$141,100*
Chlorine Storage Building	$1,700*
Total	$509,100*

[*] – Revised May 16, 2017

Additional Information from Client

Appendix B attached to this report is a copy of the Inspection of Lake Worth Casino Pool Report by Sinclair Engineering Company (SECO) dated July 9, 2012 provided to us on May 12, 2017.

The observations noted in the SECO report were reviewed, evaluated, and compared to our field notes and findings summarized in the PCA. Of particular interest were SECO's observation numbers 6 and 7 referring to a "horizontal cracks in the pool beam". After reviewing that photos in exhibit 4 of SECO's report, the mentioned horizontal crack is actually the cold joint between the structural wall of the pool and the precast coping. The coping is adhered to the top of the wall, similar to a tile installation, so a joint occurs at that interface. This joint is located at or near the finished grade elevation of the surrounding pool deck pavers and is located above the waterline This is not a structural joint and it is not meant to be watertight.

The observations noted in the SECO report do not have an impact on our original opinions and conclusions in our PCA report.

Kimley»Horn

Discussion on the Out of Scope Considerations in the PCA

The scope of our project in accordance with our agreement dated July 1, 2014 and Task Order dated April 10, 2017 was to perform a baseline Property Condition Assessment (PCA) of the Lake Worth Casino Pool and the adjacent facilities in accordance with standard ASTM criteria.

Opinions, conclusions, and recommendations provides in the PCA address the structural integrity of the pool and facilities and their potential remaining useful life based on the purpose for which these structures were created. Assessment of the functional layout of the aquatic center and marketing strategies is beyond our current scope.

Based on our original observations and additional information received, we still believe the pool and adjacent facilities can be repaired and re-used from a structural standpoint to satisfy the original needs of the facility in compliance with the Florida Building Code for Existing Buildings,

Re-use of these buildings is constrained by the existing limits of the building footprint because of their location. Changing the footprint of the buildings could require a significant permitting process because the Aquatic Complex is seaward of the Coastal Construction Control Line (CCCL).

To upgrade the pool and adjacent facilities to meet current code criteria, a change in footprint of the buildings is most likely required. An architectural evaluation would need to be performed to determine how much added square footage would be necessary to meet current code in terms of functionality, based on projected occupancy.

Programmatic and functional changes to the pool itself to attract other types of users would also need to be evaluated. Potentially, a new family-oriented complex could be designed to take advantage of the outer shell of these buildings. Desired changes in the overall complex could re-use these buildings for other purposes, such as storage, box office facilities, concessions, lifeguard lockers, etc.

The cost to restore or re-purpose these facilities would need to be weighed against the overall ultimate plan for the pool complex. A separate financial feasibility study would determine if the investment to update and maintain these facilities for the remainder of their useful life provides any benefit based on their proximity to the beach.

-------oOo---------

Kimley»Horn

APPENDIX A – EXPANDED OPC TABLE

OPINION OF PROBABLE CONSTRUCTION COST

Table 1 - expanded

The City of Lake Worth
Aquatics and Beach Complex
Opinion of Probable Cost
KH 140335001

	Material				Labor					
	Q	Unit	Unit Price	Material Cost	Hours	Rate	Labor Cost	Total Cost	OPC	
4.2 Main Lap Pool										
demolition	16801	sf	0.48	8064			0	8064		[a]
sandblast surface prep	16801	sf	2.1	35282			0	35282		[a]
floor	12300	sf	2	24600			0	24600		[a]
wall	1673	sf	2	3346			0	3346		[a]
wall	1394	sf	2	2788			0	2788		[a]
gutter	478	ft	2	956			0	956		[a]
tile	956	ft	5	4780			0	4780		
misc accessories	1	ls	2000	2000			0	2000		
Refinish the pool, including the gutters, up to the precast concrete coping.				81817			0	81817	$ 116,200	[a]
demolition/repair pool deck	500	sf	19	9500	96	45	4320	13820		
excavation	135	cy	20	2700			0	2700		
testing	5	ls	500	2500	120	45	5400	7900		
repairs	200	lf	15	3000	240	45	10800	13800		
Remove the pool deck at the four corners of the pool and at the main lines to the Filter Building to expose the return water distribution piping. Isolate and pressure test each piping leg to determine the approximate location of the leak. Inspect the pipe interior for joint separation, breaks or other defects.				17700			20520	38220	$ 54,300	
Replace the underwater lights.	22	ea	250	5500	88	65	5720	11220	$ 15,900	[a]
4.2 Main Lap Pool									$ **186,400**	[a]
4.3 Wading Pool										
Monitor Wading Pool temperatures to prevent unsafe conditions. Consider options to regulate heated water flow or provide an independent heater.					40	50	2000	2000	$ 2,800	
4.3 Wading Pool									$ **2,800**	
4.4 Pool Deck										
demolition	800	sf	4	3200	160	45	7200	10400		
excavation	59	cy	20	1185			0	1185		
repairs	200	lf	10	2000			0	2000		
restore deck	800	sf	15	12000	160	45	7200	19200		
Remove the pool deck to expose the deck drainage piping. Replace the piping and verify clear flow to the storm drain. Inspect with a plumber's camera all deck drain lines for blockage, separated joints or other defects.				18385			14400	32785	$ 46,600	
4.4 Pool Deck									$ **46,600**	
4.5 Bathhouse and Offices (Pool Restrooms)										
tear off	4392	sf	1	4392			0	4392		
mod bit roof	4392	sf	2.28	10013.76			0	10013.76		[a]
perimeter detail and expansion joint	438	lf	10	4380			0	4380		
stacks, hoods, mechanical vents	1	ls	2000	2000			0	2000		
Replace the roof covering with a modified bitumen built-up roof.				20786			0	20786	$ 29,500	
Install board insulation on the roof to meet FBC requirements.	4392	sf	4	17568			0	17568	$ 24,900	
Reconstruct ADA stalls to meet FAC.	4	ea	2000	8000			0	8000	$ 11,400	
Verify the number of fixtures based on the projected occupancy of the pool.				0	8	200	1600	1600	$ 2,300	
Redesign and replace the interior lighting to meet current FBC requirements.	4392	sf	5	21960			0	21960	$ 31,200	
demolish curb	12	lf	5	60	2	45	90	150		
slope floor topping	225	sf	2	450			0	450		
Remove the concrete curb at the men's shower room. Slope the floor to drains.				510			90	600	$ 900	
Repair damaged concrete masonry.	5.34	sf	30	160	4	45	180	340	$ 500	
The Life Guard room: Replace missing or damaged mechanical, electrical and plumbing equipment.	1	ls	500	500	4	45	180	680	$ 1,000	
The Pool Office: Replace the air conditioner with a roof mounted split system.	1	ea	800	800	8	45	360	1160	$ 1,600	
windows	8	ea	1500	12000			0	12000		
doors	3	ea	1000	3000			0	3000		
The Pool Office, Life Guard room and Manager' Office: Replace windows with impact rated windows with a Florida Product Approval or provide protective covers.				15000			0	15000	$ 21,300	
The Pool Office raise the drain.	1	ls	250	250			0	250	$ 400	
4.5 Bathhouse and Offices (Pool Restrooms)									$ **125,000**	[a]
4.5 Bathhouse and Offices (Ocean Restrooms)										
Install mechanical ventilation in mechanical room.	1	ea	500	500			0	500	$ 700	
Inspect sanitary drain lines and building sewer. Clear any blockage.	1	ls	500	500			0	500	$ 700	
Replace pipe supports.	1	ls	500	500	32	45	1440	1940	$ 2,800	
Replace missing insulation.	4	ea	150	600			0	600	$ 900	
Lower the floor drain.	1	ls	250	250			0	250	$ 400	
4.5 Bathhouse and Offices (Pool Restrooms)									$ **5,500**	

OPINION OF PROBABLE CONSTRUCTION COST

Table 1 - expanded

The City of Lake Worth
Aquatics and Beach Complex
Opinion of Probable Cost
KH 140335001

	Material				Labor					
	Q	Unit	Unit Price	Material Cost	Hours	Rate	Labor Cost	Total Cost	OPC	
4.6 Pool Filter Equipment Building										
temp support equipment	1	ls	500	500	16	45	720	1220		
truck crane	5	days	2400	12000			0	12000		
demolition	1032	sf	3	3096			0	3096		
hollow core slabs	1032	sf	12	12384			0	12384		
Remove the cast-in-place concrete roof and replace with precast, prestressed hollow core slabs.				27980			720	28700	$ 40,800	
tear off	1032	sf	1	1032			0	1032		
insulation board	1032	sf	1	1032			0	1032		
mod bit roof	1032	sf	2.28	2353			0	2353		[a]
roof top ventilators	3	ea	750	2250			0	2250		
Replace the roof covering with a modified bitumen built-up roof over 1 inch insulation board. Replace all sheet metal stacks and flashings.				6667			0	6667	$ 9,500	
Clean the corroded steel and apply a patching mortar.	2	sf	30	60	4	45	180	240	$ 300	
demolish/replace pool deck	615	sf	19	11685	96	45	4320	16005		
excavation/backfill	136.6667	cy	30	4100			0	4100		
wall penetrations	8	ea	500	4000	64	45	2880	6880		
piping	100	lf	15	1500	640	45	28800	30300		
instrumentation and controls	1	ls	5000	5000			0	5000		
start-up				0	32	45	1440	1440		
Remove the pool deck adjacent to the building and expose the piping serving the Main Pool and the Wading Pool. Replace the pool drain and return lines inside the pump room and a minimum of 5 feet outside the building.				26285			37440	63725	$ 90,500	
4.6 Pool Filter Equipment Building - Total									$ **141,100**	[a]
4.7 Chlorine Storage Building										
Replace the roof covering.	220	sf	2.28	502			0	502	$ 700	[a]
Replace damaged roof sheathing. Inspect roof framing and repair if required.	1	sht	500	500			0	500	$ 700	
Install missing fasteners into tie-beam.	1	ls	50	50	4	45	180	230	$ 300	
4.7 Chlorine Storage Building - Total									$ **1,700**	[a]
									$ **509,100**	[a]

Opinions of Cost notes:

[a] - Revised May 16, 2017

1. The costs shown in the OPC column include a construction contingency, plus an allowance for contractor insurance and bonds, and soft costs.

2. Unit prices used in the table are based on a combination of RS Means data and local price information.

3. Because Kimley-Horn (KHA) does not control the cost of labor, materials, equipment or services furnished by others, methods of determining prices, or competitive bidding or market conditions, all opinions rendered as to costs, including but not limited to opinion as to the costs of construction and materials, shall be made on the basis of its experience and represent its judgement as an experienced and qualified professional, familiar with the industry. KHA cannot and does not guarantee that proposals, bids or actual costs will not vary from opinions of cost prepared by it.

Kimley»Horn

APPENDIX B – SINCLAIR REPORT

Design With Integrity
Sinclair Engineering Company

July 9, 2012

Mr. Timothy Ehmke
City of Lake Worth
50 South Ocean Drive
Lake Worth, FL 33460

Re: Inspection of Lake Worth Casino Pool
10 Ocean Avenue, Lake Worth, FL 33460

Dear Mr. Ehmke:

Sinclair Engineering Company performed an inspection of the above-referenced public pool on June 13, 2012 in your presence and in the presence of Mr. Jamie Brown, City of Lake Worth Public Services Director.

INTRODUCTION:

Sinclair Engineering Company received your request on May 30, 2012 to inspect crack damage, an out-of-level gutter condition and related items at the Casino Pool and deck. Specifically, you requested that we determine the nature, extent and cause, if known, of pool and deck damage. You further requested that we make recommendations for repair of observed damages.

PROCEDURES:

1. The pool and deck area was examined to gain a general understanding of the layout, construction materials, overall condition and areas of damage.

2. The pool shell was examined for evidence of crack damage.

3. The pool coping was examined for evidence of damaged or missing coping stones.

4. The pool rollout gutter was examined for evidence of damage.

5. The waterline and gutter tiles were examined for evidence of damaged or missing tiles and for evidence of an out-of-level condition.

6. The pool beam was examined for evidence of damage.

7. The pool deck was examined for evidence of damage from settlement or other causes.

8259 North Military Trail, Suite 2, Palm Beach Gardens, FL 33418
561-630-5488 • Fax 561-630-4570 • sinclairengineeringcompany.com

PROCEDURES (Continued):

8. A Geotechnical Engineering Study by Tierra South Florida dated February 1, 2011, provided by you, was reviewed for content.

9. The Casino Pool file, provided by you, was reviewed for content.

OBSERVATIONS:

1. The pool can generally be described as a 3' to 12' deep, inground, gunite, rectangular-shaped public pool with a rollout gutter and raised precast coping. A sandset paver deck, over a concrete slab substrate, had been installed in association with the pool.

2. Examination of the pool shell revealed no visible evidence of cracks in the pool floor or walls.

3. Continued examination of the pool shell and gutter revealed missing bullnose tile on the inner face of the gutter, primarily adjacent to the steps in the Northeast corner of the pool.

4. Examination of the pool rollout gutter revealed that the water level was slightly higher along the West side of the pool than in the center and East side of the pool, indicating that the West side of the pool shell may have settled unevenly relative to the remainder of the pool shell.

5. Examination of the waterline tiles revealed a horizontal crack at approximately the mid-height of the waterline tiles at the back of the gutter. This condition was noted in several areas.

6. Examination of the pool beam in the Northwest corner of the pool, where a waterline tile was missing, revealed a horizontal crack in the pool beam.

7. Examination of the horizontal crack in the pool beam revealed that it appeared to be a cold joint between the previously existing concrete pool beam and a concrete overpour.

8. Continued examination of the horizontal crack in the pool beam revealed the presence of a caulking material along the crack, presumably installed to prohibit water seepage and/or prevent the crack from telegraphing into the waterline tile. It was noted that the caulking material did not extend along the entire length of the crack.

9. Examination of the precast coping stones revealed a number of cracks in the mortar joints. Further, a number of the coping stones were "hollow" and had disbonded from the pool shell.

10. Examination of the pool deck revealed that the sandset pavers had been removed in the Northeast corner of the pool. Examination of the deck in this area revealed a concrete slab substrate, portions of which had been removed, presumably to facilitate repairs in the pool perimeter gutter plumbing.

OBSERVATIONS (Continued):

11. Continued examination of the pool deck revealed no visible evidence of damage due to uneven settlement.

12. Review of the Geotechnical Engineering Study by Tierra South Florida dated February 1, 2011 revealed, in 1.0 Executive Summary, that (soil) borings B-10, B-11 and B-15 indicated the presence of about 10 feet of peat (organic soils) between a depth of about 7 and 22 feet below the ground surface. It was indicated that the borings where organic soils were encountered were on the West side in areas accessible to a truck mounted drill rig or about 75 feet away from the existing building.

13. Review of the Casino Pool file revealed numerous permits relating to the performance of routine maintenance and other work at the pool facility. Swimming Pool Alteration plans by Edgar S. Wortman, Architect, and Chester F. Wright, Engineer, were reviewed. Specifically, Drawing No. 1 of 2 dated November 1954 and Drawing No. 2 of 2 dated April 1956 were reviewed. Note that Drawing No. 2 of 2 was stamped "Approved, City of Lake Worth, 09/07/56" by Edward H. Gregory, Building Inspector.

14. Review of the Swimming Pool Alteration plans revealed that, among other alterations to be performed at that time, a rollout-type gutter was proposed to be installed on top of the existing pool wall such that it would increase the depth of the water by approximately 1 foot. Note that the pool beam details showed a monolithic pour that included the gutter and a 6" raised coping section. Further note that the horizontal crack discussed in Observation 7. did not correspond to the construction joint between the existing pool shell and the concrete beam overpour. Rather, the horizontal crack discussed in Observation 7. was in the upper area of the pool beam below the coping.

CONCLUSIONS:

Based on field-observed conditions and related experience, the conclusions of this inspection are, to the best of my professional understanding and belief, as follows:

1. There is evidence of uneven settlement of the pool which may be the result of organic soils underlying the pool and deck. Soil testing in locations proximal to the settled section of the pool would be required to confirm this condition.

2. There are horizontal cracks in the pool beam at a cold joint from previous alterations.

3. The proper repair of the pool beam is as follows:

    a. Remove the precast coping stones (reserve for re-use) and waterline tiles from the entire perimeter of the pool.

    b. Remove the portion of the pool beam above the crack from the entire perimeter of the pool.

    c. Acid-etch and neutralize the top of the pool beam.

CONCLUSIONS (Continued):

d. Install a properly-reinforced and attached pool beam.

e. Replace the precast coping stones and install new waterline tiles.

4. There are disbonded / loose precast coping stones which are to be reinstalled with an elastomeric thinset.

5. It is also recommended that the precast coping stone mortar joint be filled with elastomeric grout to allow for expansion and contraction forces between the coping and the pool shell. Note that this expansion joint is to be installed on 10' to 12' centers and at the corners.

6. If future soil testing confirms the presence of organic soils underlying the pool and deck, a piling foundation would be required to properly support the pool and prevent future movement. This office can produce pool and deck repair plans, including a pool piling plan, as requested. Alternately, the pool beam elevation can be monitored periodically (every one to three years) to determine if pool settlement is ongoing.

CLOSURE:

The professional services and independent opinions provided are based on the standards generally accepted within my area of expertise and in accordance with industry professional and ethical guidelines applicable to structural engineering. The opinions stated herein are my own and, if necessary, I will testify in support of the conclusions contained in this report.

Thank you for selecting Sinclair Engineering for your engineering needs. Please feel free to contact this office for further information as the need arises.

Respectfully submitted,

July 9, 2012
Stephen M. Sinclair, P.E.
FL Lic. No. 35631

STEPHEN M. SINCLAIR LICENSE No 35631 STATE OF FLORIDA PROFESSIONAL ENGINEER

Copy: 12-06000

06-13-12 Inspection Report 07-09-12

EXHIBIT 1. OVERALL VIEW OF POOL AND DECK LOOKING NORTHWEST

EXHIBIT 2. OVERALL VIEW OF POOL AND DECK LOOKING SOUTHWEST

EXHIBIT 3. VIEW OF NORTHWEST AREA OF POOL

EXHIBIT 4. VIEW OF CRACKED WATERLINE TILES AND CRACKED POOL BEAM

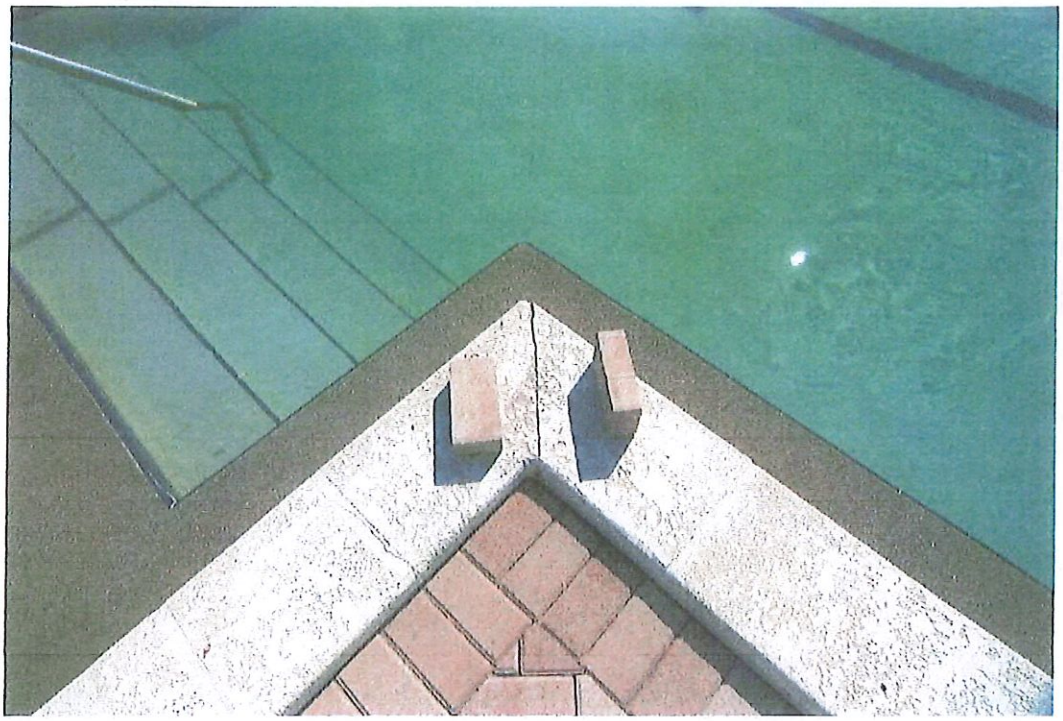


EXHIBIT 5. VIEW OF CRACKED MORTAR JOINT BETWEEN ADJOINING COPING STONES

EXHIBIT 6. VIEW OF STEPS IN NORTHEAST AREA OF POOL

EXHIBIT 7. VIEW OF MISSING BULLNOSE TILE (REFERENCE EXHIBIT 6.)

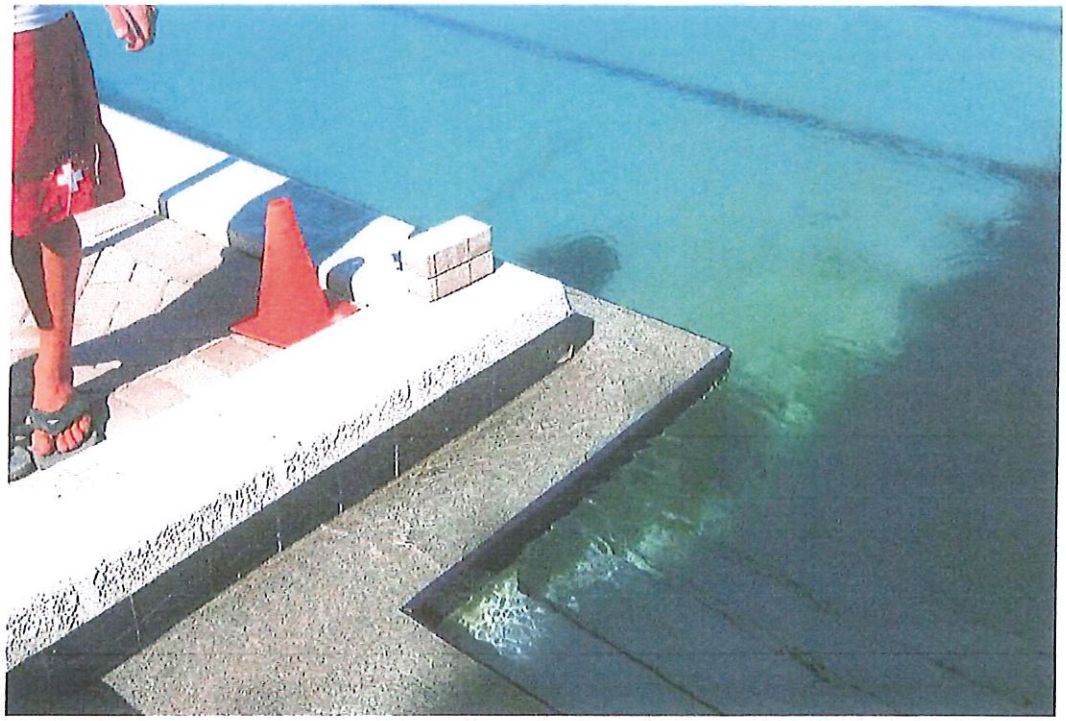


EXHIBIT 8. VIEW OF HORIZONTAL CRACK IN WATERLINE TILES (REFERENCE EXHIBIT 6.)

SINCLAIR ENGINEERING COMPANY
Design With Integrity
Sinclair Engineering Company

October 1, 2012

Mr. Jamie Brown, Public Services Director
City of Lake Worth
1749 3rd Avenue South
Lake Worth, FL 33460

Re: Cost of Pool Repairs
Lake Worth Casino Pool, 10 Ocean Avenue, Lake Worth, FL 33460

Dear Mr. Brown:

Sinclair Engineering Company received your request to provide the cost associated with repairs to the Lake Worth Casino Pool.

The information contained herein is provided as supplemental information to my Inspection Report dated July 9, 2012.

Please note that the Scope of Work in the Estimate provided by Barrow Pools includes:

1. Remove and replace existing pool beam above crack
2. Remove (2) layers of waterline tile and replace with new tile
3. Remove (2) layers of gutter bullnose and replace with new tile
4. Remove existing pool finish as needed in areas of delamination
5. Remove and replace step tile
6. Install cast in place 12" x 24" x 3" coping
7. Remove and replace new lane markers
8. Pressure test plumbing lines as needed (this test is not included in the price, time and material)
9. Prepare pool liner
10. Plaster pool with Petite Pearl, owner to choose color
11. Fill pool with carbon tanks

8259 North Military Trail, Suite 2, Palm Beach Gardens, FL 33418
561-630-5488 • Fax 561-630-4570 • sinclairengineeringcompany.com

The cost for the above Scope of Work, excluding pressure-testing of the plumbing lines, is $198.761.00.

If, during removal of the pool beam, more extensive damage is found, the beam and gutter will be rebuilt as needed to 6" below the existing gutter at an additional cost of $24,600.00, see Option.

Lastly, please note the Upgrade of plastering the pool with Pebble Sheen Finish at an additional cost of $71,520.00 which would allow the pool to remain empty when not in use.

Thank you for selecting Sinclair Engineering for your engineering needs with your pool project. Please feel free to contact this office for further information as the need arises.

Respectfully submitted,

October 1, 2012
Stephen M. Sinclair, P.E.
FL Lic. No. 35631

Attachment: Barrow Pools Estimate
Copy: Job 12-06000, Chief T. Ehmke (by E-mail to Ehmke@LakeWorth.org)

Barrow Pools

720 Kittyhawk Way
North Palm Beach, Florida 33408

Estimate

Name / Address
Lake Worth Casino Attn: Steve Sinclair

Date
9/13/2012

Description	Total
Scope of work to include: Remove and replace existing pool beam above crack Remove two (2) layers of waterline tile and replace with new tile Remove two (2) layers of gutter bullnose and replace with new tile Remove existing pool finish as needed (delimitation) Remove and replace step tile Cast in place 12" x 24" x 3" coping Remove and replace new lane markers Pressure test plumbing lines as needed (Not included in price, time and material) Prep pool liner Plaster swimming pool with Petite Pearl color choice by owner Fill pool with carbon tanks **Option:** **Rebuild beam and gutter as needed to 6" below existing gutter - $24,600.00** Upgrade: Plaster pool with Pebble Sheen Finish - $71,520.00	198,761.00

Phone #	Fax #	E-mail
561-582-5200	561-745-2266	barrowpools@bellsouth.net

Bob McCallister
Aquatic Consultant

City of Lake Worth Aquatic Facility Survey and Report

Re: Repairs, Upgrades and Improvements
Report Prepared by Bob McCallister, Aquatic Consultant
December 2016

Scope of Service

Aquatic Consultant surveyed and inspected the Outdoor Pool and accompanying facilities. The Aquatic Consultant prepared the following comprehensive report with recommendations for repairs, upgrades and facility improvements. Recommendations have been included in this report for the City of Lake Worth to have the opportunity to choose the level of repairs and improvements based on budget constraints.

The Aquatic Consultant has thoroughly researched cost estimates for all components contained within the report including materials, equipment and labor. The report is divided into 2 categories: 1) Pool/Filtration System and 2) Buildings, Structures and Grounds. The estimated pricing is included in this report for the purposes of development of a project budget and an RFP for the work.

Additionally, the Aquatic Consultant provided an updated business plan and budget including operational cost and revenue projections based on the improvements to the Aquatic Facility.

Finally, there is an Executive Summary provided at the end of this report excluding the technical and financial information within this report for a quick overview.

Pool and Filtration System

Pool and Wading Pool

The pool is a 50-meter by 25-yard competitive swimming pool with a 1-meter diving board and diving well. The pool is 3.5 ft. at each end and tapers down toward the center to a 12 feet depth. The 50-meter pool holds approximately 750,000 gallons of water. The wading pool is 16 ft. by 40 ft. and contains approximately 8,000 gallons of water. Both pools have a marcite (plaster) type finish that was coated over an epoxy paint type finish and as a result is delaminating in several areas. Lane markers and pool trim are ceramic tile.

There are 4 main drains in the 50-meter pool which do not work as marcite material was left in the main drains during the installation and never removed. Federal Law regulates the main drains in public pools. The Virginia Graeme Baker Act (VGB) was passed in 2008 mandating that all public swimming pools have a main drain per the requirements outlined in the VGB Act. Currently, both pool main drains are not compliant nor do they provide for the proper drain flow for pool circulation.

The 50-meter pool has a stress fracture in the perimeter gutter primarily on the east side of the pool. The pool had a major leak on the northeast corner of the pool under the pool deck that was losing several thousand gallons of water daily until it was discovered and repaired this past summer. This water leak continued for several years causing the original concrete deck to be undermined and settle. This scenario may have caused the fractures in the gutter, but mostly caused the original deck to crack. The original deck has been covered with sand based pavers that are covering the settling deck. The pool deck drains on the east side do not function and appear to be clogged by sand or other materials.

The Wading Pool has an underground leak in the main drain line outside the fenced area leading back to the filter room and is showing up as sand and water entering into the filter room on the northeast wall where the main drain line returns into the filter system.

Pool and Wading Pool Needs		Cost Estimate
• Main drain sump boxes and 4" drain lines clearing and compliance to VGB		$ 10,000
• Remove failing marcite coating and epoxy paint from both pools and re-marcite		$ 150,000
• Discover and repair leak in main drain line in the wading pool and repair.		$ 5,000
• Replace all lane line and trim ceramic tiles in both pools		$ 12,000
• Cut channels in stress fractures fill with hydraulic cement and finish with marcite		$ 3,000
• Pull up deck pavers every 5' along the perimeter of the northeast sides of the 50-meter pool for the length of both 25-yard and 50-meter and sound check on original deck for voids from pool leak erosion. Discover voids and back fill voids and replace pavers as needed to finish.	Allowance	$ 20,000
	Sub-Total	$ 200,000

Pool and Wading Pool Optional Improvements

Convert the 50-meter pool to a zero depth entry on south end; convert 12' deep main drains to a 4.5' depth; convert pool return lines to assure pool water circulation per national swimming pool standards; includes refinish of marcite and tile work. Remove starting blocks on south end and diving board standards. Budget $ 500,000

Install water interactive spray features (8 above pool water surface and 12 floor geyser type) in shallow end down to 1.5' depth. Install 4-sets of 8 deck sprays along east and west sides of the shallow end of pool from 1.5'depth to 4' depth. Install 4 – 8' in-pool benches on east and west sides of shallow end from 2.5' to 4' depths. Includes spray feature supply drains and spray feature pump, manifold and transport water lines.	Budget	$ 350,000
Install 2 – 150' waterslides off of 1 – 25' tower to exit into shallow end of pool in 4' to 4.5' water. Includes slides supply drains and slide pumps and transport water lines.	Budget	$ 350,000
Demolish Wading Pool, bench and shade structure. Build "Tiki Hut" type bar, shade structures with tables and Chairs; design and structures to be within the 44' x 60' footprint of the wading pool area.	Budget	$ 75,000
Remove existing 10' x 50' shade structure on the south end of the pool and replace with "Sail" shade type structures.	Budget	$ 35,000
	Improvements Sub-Total	$1,310,000

Buildings, Structures and Grounds

Bathhouse and Offices

The existing bathhouse and offices were built in 1971. There have been several renovations to the building over the years including restrooms added to the south end of the building for public beach patrons. The footprint of the building is approximately 185' x 24'. There are many current issues including: roof structure failing; rusting of metal fixtures, toilet wooden partitions; poor lighting, exposed electrical conduits; inadequate showers and no handicapped showers; inadequate staff space for offices; and un-inviting and inconvenient front entrance.

The facility's footprint is a total of approximately 35,000 sq. ft. The pool is 13,800 sq. ft.; pool/pool deck and wading pool footprint is 29,226 sq. ft. The current bathhouse is 4,810 sq. ft.

Staff reports that the bathhouse was condemned due to the roof issues a couple years ago.

It is the recommendation of the Aquatic Consultant that this building be demolished and a new structure be rebuilt outside of the south side pool and deck footprint. In addition, the new building would be a two-story structure with the bathhouse entrance, bathrooms/showers, lifeguard room, pool storage and pool manager office located on the first floor level. The second floor would house staff offices, a patio pavilion for public use and/or private rentals and a concession stand. On the east end of the first level, a separate public restroom apart from the pool operations would be built to service the beach patrons as the original building provides. A half basement on the west side of the bathhouse

would house a garage for beach lifeguard equipment, a beach lifeguard room, bathroom and exercise room. The basement would also house the new filter room as described in sections below.

The building would be approximately 140' x 30', with 10,500 sq. ft. of total usable space.

In addition, the footprint of the existing building would become additional pool deck space with shade structures, deck furniture, and a 155' – 2' wall with a plexi-glass type windshield. This area would provide beach and ocean views as well as a public view of the new aquatic facility from the beach and drive.

Calculation:	Building 10,500 sq. ft. x $185/sq. ft.	$ 1,942,500
	Piling type foundation allowance (required)	$ 200,000
	Elevator at Park Lot level to 3rd floor	$ 25,000
	Demolition allowance for bathhouse and filter room	$ 100,000
	Additional pool decking 2,880 sq. ft. allowance	$ 40,000
	185' - 2' Wall and 6' plexi-glass wind shield allowance	$ 20,000
	Budget	$ 2,322,500

Filter Room

The existing filter room is in worse condition than the bathhouse. The roof structure is failing and currently being supported with 2' x 4's and plywood. The pumps, piping, valves, gauges are in poor condition and are in questionable condition as to meeting proper filtration standards. The pool heaters are scheduled to be replaced for the coming winter season. The electrical components, including VFDs and electrical panels providing pump motors and control, are corroding and in poor condition and/or not working.

It is the recommendation of the Aquatic Consultant that this building and equipment be demolished and rebuilt and equipped.

Equipment Budget	$250,000
Filter Building Budget	$ 50,000*
Total	$300,000

*Note: Building Budget to be subtracted if new bathhouse plan is selected.

Summary Review of Options and Resulting Projected Attendance and Revenue

Option 1.	Pool and Wading Pool Needs -	Budget	$ 200,000
	Bathhouse and Offices	Budget	$2,322,500
	Filter Room	Equipment Budget	$ 250,000
		Total	$2,772,500

Option 2. Conversion of 50-meter pool to zero depth entry on south end.

Option 1 Budget	$2,772,500
Conversion Budget	$ 500,000
Total	$3,272,500**

**Note: If Option 2 is chosen, then Options 3 & 4 should be strongly considered as pool piping for these options should be installed below the deck and pool shell before the conversion of the 50-meter pool to

a zero depth pool. Also, the new filter room will need to be designed to receive the spray features and waterslide pumps, piping and controller equipment.

Option 3. Install water interactive spray features

Option 2 Budget	$ 3,272,500
Spray Features Budget	$ 350,000
Total	$ 3,622,500

Option 4. Install 2 – 150' waterslides off of 1 – 25' tower

Option 3 Budget	$3,622,500
Waterslides Budget	$ 350,000
Total	$3,972,500

Option 5. "Tiki Hut" type bar and patio

Option 4 Budget	$3,972,500
Tiki Hut Budget	$ 75,000
Total	$4,047,500

Option 6. "Sail" shade type structures

Option 5 Budget	$4,047,500
Sail Shade Budget	$ 35,000
Total	$4,082,500***

***Note: If the City decides to proceed with this project, there should be a budget line item for FF&E of $100,000. This will allow for purchasing of deck furniture, office furniture and computers for POS and management tracking of revenue, concession stand equipment and possibly a security camera system. In addition to the FF&E, it is recommended to add a contingency of 5% or $215,000; and another 5% or $215,000 for architectural services.

Total All Inclusive Construction Budget **$4,612,500**

Projected Revenue and Operational Cost

Option 1.

The Pool operations currently cost approximately $300,000 annually. The total annual revenue is $66,000 from approximately 10,000 annual users, plus $33,000 from swim team rentals. The pool is currently open 29 hours a week with lifeguard supervision. The pool rentals for swim teams are not staffed with City staff lifeguards.

With the repairs to the pools and replacement of the bathhouse and filter room, the only difference is would be providing a much better view of the pool from the beach and from the pool to the beach. This alone would give a good potential for increased usage of the facilities for rental functions and drawing swim patrons to the pool.

Option 1's minimal and necessary improvements could potentially increase individual and family patronage by 25%. The average revenue per current patron calculates to $6.60 per user. The 25% increase in patronage to 12,500 could bring the revenue to $82,500.

The operational cost could remain at the current $300,000 annual cost. However, if the demand for increased operation hours comes about by the simple marketing of the facilities being visible, new and attractive, the City may consider increasing operational hours. This would cause a need for additional staff and operational cost. Therefore, this option has the minimum potential of recovering $116,500 of a $300,000 cost of operations or 38% over the now 33%.

Option 2.
Conversion of the 50-meter pool to a zero depth entry and shallow water pool throughout will be more family friendly and attendance would increase substantially. However, this conversion would not reach the maximum potential for revenue and attendance without the water slides and spray features.

The Aquatic Consultant does not recommend that Option 2 stand-alone as the national and international trend in aquatic facilities is for water parks and spray features. These water park type facilities are mostly self-supporting facilities and would prove to be the case with the City of Lake Worth's new aquatic facility.

Options 2, 3 & 4
Combining these three options would give the City an attractive and exciting family oriented aquatic facility that would become a destination venue for the community and visitors. With this type of aquatic facility, the public demand for more operational hours is highly likely and therefore an increase in the operations budget would be necessary.

The family water park type facility would require additional staffing including: lifeguards, attendant staff for cashier operations and concession operations. In addition, the new high technical filters, controllers and water feature pump motors would need to be maintained 7 days a week. The facility would need thorough cleaning daily and continually during operational hours.

Financially, choosing Options 2-4 would require an annual operational budget of $476,651 with revenue is projected at $453,000, leaving an annual City subsidy of $23,651. (See pages 7 & 8)

Options 5 & 6
Adding Options 5 & 6 to Options 2, 3 & 4 would enhance the attendance and revenue potential. It would most likely allow the new aquatic facility to break even and/or become 100% self-supporting.

Financially, the revenue potential is projected over the $476,651 operational cost, thus self-supporting.

(Continue to next page)

City of Lake Worth Aquatic Facility
Estimated Operations Budget
Options 2-4

Operations Outline

Facility open Tuesday – Sunday year round Average 8 hours per day; Average 6 lifeguards; 1-2 attendants; 1 – PT Supervisor. ; 1- PT Asst. Supervisor; 1 – Admin. Asst. (40hrs.); 1 – Facility Mgr. (40hrs,); 1 – Pool Operator (40hrs.)

Expenditures:

Staffing – Full Time		
1 Facility Program Mgr. (currently on staff)	35,000	
1 Admin. Asst. (Cashier/Receptionist)	26,250	
1 Pool Operator/ Mt. Worker	32,500	
Benefits & FICA (27%)	34,675	
Subtotal full time staff		128,425
Part Time Staff		
2 PT Supv. @ 1400 hrs. ea, ($12/hr.)	33,600	
2 PT Asst. Supv. @ 1400 hrs. ea. ($11/hr.)	30,800	
24 PT Lifeguards @ 5-29 hr./wk. (9.50/hr.)	150,000	
4 Attendants @ 5-29 hr./wk. $8.50/hr.	12,000	
Conc. Workers (Contract Concession)	na	
FICA (6%)	14,451	
Subtotal part time staff		240,851
Operation Supplies		
Office Supplies	500	
Computer Supplies	375	
Janitorial Supplies	2500	
Recreational Supplies	6,000	
Program Materials and Supplies	1,500	
Uniforms	4,000	
Safety Supplies	1,000	
Chemicals (corrected over budgeted 1st draft)	25,000	
Accountable Equipment	3,000	
General Printing	750	
Repairs/Maintenance (Outside Warranty)	11,250	
Subtotal operation supplies		55,875

Utilities		
Communications (phone, Internet, security)	3,000	
Electric	30,000	
Gas	12,500	
Water/Sewer	6,000	
Subtotal Utilities		51,500
Total Expenditure Budget		**$476,651**

City of Lake Worth Aquatic Facility
Estimated Operations Budget
Options 2-4 Revenue Projections
Revenue increase is based upon an average150 patrons for 300 good weather days @ average of $6.60 Note: During Private Rentals and Swim Team Rentals require off-duty City lifeguards that are to be paid by the rental group at $15/hr./lifeguard

Admission Fees	(45,000 patrons)	297,000
Facility Rental Fees	(50 rental @ $500)	25,000
Swim Team Rental	(25 yard lanes only)	66,000
Instructional Classes	(Swim/Exercise Classes)	50,000
Concessions/Resale	(15% of Gross Sales)	15,000
	Total Revenue	**453,000**

Revenue:	Fee Levels
General Admission	Adult $7.50 & Youth/Sr. $5
Swim Team Lane Rental	$10.00/25 yard lane/hr.
Recreational Pool Rental	$500/2 hrs.

Expenditure Budget	$476,651
Revenue Budget	$453,000
City Annual Subsidy	$ 23,651****

****Note: The addition to the facilities with Options 5 & 6 may increase rentals and concession revenue to exceed the City Subsidy to become a break-even budget or generate revenues above expenditures.

Budget and Marketing Note
Currently, Lake Worth City Beach has an annual attendance of 700,000. The Budget revenue projections are very conservative in this report. With the opening up of the beach view from the Water Park and view of the Water Park from the beach, the attendance to the Water Park will increase substantially and revenues will exceed accordingly. It is the projection of the Aquatic Consultant that the proposed improvements will in fact result in revenues exceeding the expenditures during the first year of operations.

Executive Summary

Based upon this completed study, it is the recommendation of the Aquatic Consultant that renovations and improvements to the existing Aquatic Facility at Lake Worth Beach would not be cost effective nor serve the Lake Worth community and visitors to the best interest of the City of Lake Worth.

It is the professional opinion of the Aquatic Consultant that this Aquatic Facility be closed until the bathhouse and filter room are totally rebuilt due to exposing the public and staff to the present hazardous conditions.

This report clearly identifies the need to demolish and rebuild the bathhouse and filter room. In addition, there are major repairs and modifications needed to the pool structure and filter system. These items alone will cost approximately $2.8 million and will not substantially increase the aquatic facility's current use nor will the annual revenue increase.

Converting the 50-meter pool into a shallow water entry pool with interactive water features and amenities may increase the pool's attendance at a cost of additional $1.2 million. With the addition of architect/engineering and pool designer fees, a contingency fund of 5% and FF&E budget of $100,000 **the total project approaches $4.6 million.**

Further, the Aquatic Consultant recognizes that during any renovation project there may be some unforeseen problems during the renovation and/or future problems with what remains regarding the old 50-meter pool.

It is the Aquatic Consultant's professional opinion that it would be a better decision for the City to totally rebuild a new family water park with lap lanes on the same footprint location. Use the same footprint with all the water features in this report and possibly add more features, such as a lazy river. This could be done for $4.5 - $5 million and would be a better use of the funding, than to try to save one end of the existing 50-meter pool. This new aquatic facility will have the potential to be self-supporting, as the revenue generated would cover the annual operational expenses.

Finally, it should be noted that a water park facility of this nature and at this location would require at least 300 additional parking spaces. This may require a new parking deck adjacent to the water park. This is an additional component to this report and would require additional funding above the $4.5 - $5.0 to the new water park concept for parking deck design and construction cost.

-End of Report-

STAFF REPORT
SPECIAL MEETING

AGENDA DATE: May 9, 2024 **DEPARTMENT:** Community Sustainability

TITLE:

Discussion regarding the use of Artificial Turf

SUMMARY:

Continued discussion seeking policy direction on the appropriate use of artificial turf and whether it should remain prohibited as a replacement for required landscaping

BACKGROUND AND JUSTIFICATION:

At present, the City's Land Development Regulations prohibit the use of artificial turf as a replacement for required landscaping as outlined in the City's Landscape Code. There has been much discussion regarding its appropriate use or not. Provided here are items that previously have been provided to the Commission on this topic. Please keep in mind that the City's Code of Ordinances only prohibits the use of artificial turf when installed in the place of required landscaping. The Code is either silent or implies the allowance of artificial turf in other application types such as exterior decoration of the façade of buildings, pool deck covering where the pool deck is an impermeable surface, sidewalk and porch deck coverings and possibly other applications that are not associated with required landscaping.

Previous policy direction has been to uphold the City's prohibition of artificial turf regarding required landscaping. However, policy regarding the other applications of the material in other instances was not so clear. In addition, there has been much public demand for an opportunity for the public to be heard on this issue.

MOTION:

Move to approve/disapprove continued prohibition of the use of artificial turf in place of required landscaping materials

ATTACHMENT(S):

Fiscal Impact Analysis -N/A
Artificial Turf Workshop Staff Report
Artificial Turf in Neighboring Cities
Attachment A
Attachment B
Tree Board Minutes 03.16.2023

from Commissioner Diaz:
FL Statute – landscaping
UF – synthetic turfgrass paper
Effects of landscape composition paper
Summer heat article
Health impacts paper
Tests paper

STAFF REPORT
WORK SESSION

AGENDA DATE: April 13, 2023 **DEPARTMENT:** Community Sustainability

TITLE:

Landscape and Artificial Turf Staff Report

SUMMARY:

The City Commission paused Code Compliance actions on all violations relating to groundcover including artificial turf for 90 days beginning January 11, 2023, to hold a work session meeting to discuss the ordinances regarding artificial turf and the installation of groundcover in yards with mulch or rock. The reference materials for this item include a link to the City's "Landscape and Trees" webpage, draft language that was pulled (not adopted) from Ordinance 2020-15 on artificial turf, and a summary of the potential impacts of rock yards.

The City's Landscape Regulations (Sec. 23.6-1. – Landscape regulations), which utilizes a point system by development type, can be accessed via the City's "Landscape and Trees" webpage at: https://lakeworthbeachfl.gov/landscaping-and-trees/. The links on the page provide helpful information for residents and property owners, including a link to the University of Florida IFAS Florida Friendly Landscaping Program's webpage.

BACKGROUND AND JUSTIFICATION:

Artificial Turf:

Attachment A includes the draft artificial turf code provisions that were pulled (not adopted) from Ordinance 2020-15 as background material. These draft regulations included limits on the location, application, and amount of artificial turf. As artificial turf is not a landscape material, the draft language treated it as a semi-permeable material similar to gravel, permeable pavers, or permeable asphalt. The language also provided quality standards for visual appearance and safety as artificial turf comes in a wide variety of grades. Also included in Attachment A is the 2020 staff presentation on the pros and cons of artificial turf and a summary of the proposed code language at that time.

Landscaping Areas in Yards:

The City's Landscape Regulations (Section 23.6-1.) requires the implementation of Florida-Friendly Landscaping Principles, which are 9 science-based principles for sustainable landscapes. These principles were developed by the University of Florida's IFAS and are the foundation of the University's Florida Friendly Landscaping Program. The City's Landscape Regulations employ a point system in addition to minimum requirements for screening and shade trees for the two different categories of development: "New and existing single-family and duplex properties" and "New and existing multiple-family, commercial and industrial development." As consistent with the City's water conservation objectives in the Conservation Element and Florida Friendly Landscaping principles, the code does not require or encourage sod/grass/turf. The code also provides installation specifications so that living ground covers and native grasses used in lieu of turf or sod will have "a finished appearance and reasonably complete coverage within six (6) months based on the expected mature spread."

In addition to the requirements in Section 23.6-1, there is a provision in all of the City's residential zoning districts and the Mixed Use – East zoning district that "the lesser of nine hundred (900) square feet or seventy-five (75) percent of the front yard area shall remain pervious and be landscaped." The landscape

code and district requirements were intended to maintain and expand the green/tropical visual corridor along the City roadways, and to maximize shade for pedestrians.

While rock yards or rock as mulch are installed in the region, they are not considered Florida-Friendly by the University of Florida, and are discouraged for the reasons provided in Attachment B. Rock as mulch is only recommended by the program in limited applications. However, due to requests by residents in recent years to utilize more rock in their landscape areas, rock was permitted as a mulch substitute. Regardless of the type of mulch selected, a "landscape area shall contain a maximum of fifty (50) percent mulch or rock in planting beds" (Section 23-1-12). Substantial expansion of rock yards or expanses of rock in landscape areas would likely impact the visual corridor over time and have environmental impacts (Attachment B) as approximately 67% of the City's land area is in a residential zoning district..

DIRECTION:

Bring forward/not bring forward an ordinance allowing artificial turf with limitations as directed by the City Commission

Bring forward/not bring forward an ordinance modifying current yard landscaping requirements as specified by the City Commission

ATTACHMENT(S):

Attachment A – 2020 Previously Proposed (NOT ADOPTED) Artificial Turf Regulations & 2020 Staff PowerPoint Slides on Artificial Turf
Attachment B – Rock Yards & Mulch

Artificial Turf Requirements in PBC Local Governments

Local Government	Artificial Turf Allowed Yes/No	Regulations
Boca Raton	Yes, Limited to residential	Historically permitted in residential front, side, and rear yards subject to drainage review.
Boynton Beach	Yes, treated as impermeable surface	For Residential, artificial turf is allowed in back yards and treated as impermeable/paving, which has setback requirements. No specific regulations have been adopted. It is treated as pavement
Delray Beach	Yes, currently very limited New LDR Amendment in Process	Artificial turf is currently permitted in sidewalk cafes through the City's sidewalk café permitting process. LDR Section 6.3.3(f)(12): (12) The use of carpeting, artificial turf, or other services of any kind must be approved as a part of the Sidewalk Café application. Delray Beach staff is currently working on finalizing an ordinance to allow artificial turf as hardscape surface with performance standards. The draft ordinance was reviewed by the City's Planning and Zoning Board on March 20, 2023 to provide feedback to staff. In the draft ordinance: • Artificial turf is considered hardscape, and must be designed and permitted with a minimum permeability of 30 inches per hour per square yard. Artificial turf cannot be used within permanent drainage features (ponds, swales, etc.). • Artificial turf may be used in combination with living plants as part of a landscape design, but artificial turf shall not by itself constitute landscaping. No more than 15 percent of the lot area remaining after building coverage, open space, and hardscaping are subtracted from the total lot area may be comprised of artificial turf.
Greenacres	No	Not permitted, staff is reviewing issue
Jupiter	No	Definition of Turf: means continuous plant coverage consisting of grass species suited to growth. Jupiter staff is beginning to research and draft regulations to potentially allow artificial turf as an impervious surface (e.g. patio area). Draft regulations are tentatively scheduled to go to public hearing sometime in Winter 2023/2024.
Lantana	Yes	Sec. 10.5-23(e) provides performance standards, but no limitation on the application of the material. Sites have to comply with all landscaping requirements, but may also utilize artificial turf.

Local Government	Artificial Turf Allowed Yes/No	Regulations
Palm Beach County	Yes	ULDC. Article 7 Section 7 E Artificial turf may be installed in the interior, terminal, or divider medium of a bull pen vehicle storage area. The applicant shall receive product approval from the Zoning Director, prior to indicating in the Landscape Plan or installation. Article 7 Section 7 E No artificial plants or vegetation shall be used to meet any standard of this article. Chapter E section 6 Artificial turf has also been permitted on athletic fields in recent approvals.
Palm Beach Gardens	Yes Allowed in limited areas. Code also has performance standards	Sec. 78-321. - Minimum landscape and hardscape standards: (c) Artificial turf. Up to one hundred (100) percent of the recreational use (e.g., playground, athletic field) of artificial turf shall be permitted to count toward open space requirements. Artificial turf shall consist of green lifelike individual blades of grass that emulates natural turf. The installation of artificial turf shall not restrict or compromise the health or maintenance of natural vegetation required by any other section of this Code. The location of artificial turf shall be limited to the following: (1) In residential lots, the quantity of artificial turf is restricted by the maximum percentage of impervious surface for the subject property permitted within the applicable zoning district. (2) Artificial turf is not permitted within required landscape buffers, parkways, or preserve areas. Sec. 78-322. - Hardscape and nonliving landscape materials installation requirements: (f) Artificial turf. Artificial turf shall be designed for the intended use and meet the appropriate industry standards for installation, drainage, and aesthetics. Artificial turf shall resemble a natural turf/sod/grass look at all times. Artificial turf shall be visually level, with the grain pointing in a single direction. The improper maintenance or disrepair of artificial turf shall be a violation of the city's Code, which may include, but not be limited to, unanchored areas, water pooling, and/or unsightly or unclean areas.
Palm Springs	No	Not permitted
Wellington	Yes, Allowed in limited areas. Code also has performance standards	Chapter 8, Section 7.8.1 K. The limited use of artificial/synthetic turf, grass, sod, lawn, etc., is allowed per the following standards: 1.The use of artificial turf is limited to the following uses: a. Residential properties: Allowed in the rear and side yard areas if not visible from the right-of-way. Rear and side yard areas where artificial turf is visible from the right-of-way shall be screened from view by continuous opaque fencing or hedge material with a minimum height of five feet. Artificial turf shall be prohibited in front yards, except for the limited use as a decorative grid design with maximum four-inch wide strip used in conjunction with approved pavement materials for patio, walkway and driveway as approved with a building permit for the improvement. ….Continued on next page…

Local Government	Artificial Turf Allowed Yes/No	Regulations
Wellington* *Continued from previous page	Yes, Allowed in limited areas. Code also has performance standards	b. Residential common areas: Allowed in areas designated as recreation or amenity areas on the approved site plan. c. Non-residential: i. Commercial: Allowed in areas that are not required to meet the minimum landscape requirements and shall be designated on the approved site plan. Artificial turf shall be prohibited in designated landscape buffers, areas adjacent to, or visible from, any rights-of-way, drainage and swale areas, lake/canal bank, or other areas within the site that are not required to meet the intent of the landscape requirements as determined during the site plan review process. ii. Recreational areas: Allowed for athletic/activity fields, as designated on an approved site plan. All athletic/activity fields shall be designed to meet the industry standards for the intended use.
West Palm Beach	Yes, Allowed in limited areas. Code also has performance standards	Sec. 94-451. - Artificial turf. (a) The use and location of artificial turf shall be limited to the following: (1) The construction of non-city-owned athletic fields and playgrounds associated with a non-city-owned community center, park, school, or university; (2) As part of the construction of any nonresidential development; (3) On roof top terraces; (4) On residential lots in the rear setback and side setback; or (5) In multifamily residential developments as part of a recreation or amenity area.

FOR REFERENCE ONLY - NOT ADOPTED OR PROPOSED

Attachment A:
Previous DRAFT Artificial Turf Exhibit
that was stricken from Ordinance 2020-15 on November 17, 2020

Chapter 23

ARTICLE 6 "ENVIRONMENTAL REGULATIONS"

Sec. 23.6-1. - Landscape regulations.

***

(k) *Landscape design standards*. The following are the minimum standards for the design and installation of all landscaping within the City of Lake Worth Beach:

***

(15) *Artificial turf.*

a. All installation of artificial turf shall require a landscape permit. The use and location of artificial turf shall be limited to the following:

(1) Single family and duplex properties in the rear yard only and not visible from the right of way.

(2) Between parking strips in the front yard of non-conforming properties previously constructed with off-street parking utilizing sixty percent (60%) or more of the width of the front yard. This application of artificial turf shall be approved by the Development Review Official or applicable review board, which shall review the proposed application for consistency with the City's land development regulations, visual appropriateness, enhanced site design and appearance, and improved drainage.

(3) On roof top terraces.

(4) As part of a planned development in a recreation or amenity area.

b. In all areas of installation, artificial turf shall be treated as a semi-pervious surface. The quantity of artificial turf to be incorporated into a project shall be limited by the maximum percentage of impervious surface for the subject property within the applicable zoning district.

c. Artificial turf shall not be installed:

(1) as part of any landscape buffer or landscape area required by this article;

(2) within permanent drainage features (e.g., ponds, swales); or

(3) in any public right of way.

d. Minimum material standards. All artificial turf shall comply with each of the following minimum standards:

(1) Artificial turf shall consist of green lifelike individual blades of grass that emulate natural turf in look and color and shall have a minimum pile height of one- and one-half inches and shall have a minimum tufted weight of 80 ounces per square yard.

(2) Artificial turf installations shall have a minimum permeability of 30 inches per hour per square yard.

(3) All artificial turf shall have a minimum ten-year manufacturer's warranty that protects against color fading and a decrease in pile height.

(4) Artificial turf shall be lead free and be partially or wholly manufactured from recyclable materials.

(5) All materials must include test documentation which declares that the artificial turf yarn and backing materials are disposable under normal conditions, at any U.S. landfill station (Total Content Leach Protocol (TCLP) test). Documentation must also be provided that identifies all components that are recyclable and all components that consist of recycled material.

(6) The use of indoor or outdoor plastic or nylon carpeting as a replacement for artificial turf or natural turf shall be prohibited.

(7) The artificial turf system shall utilize organic plant-derived and other natural infill components, including, but not limited to, cork, coconut, corn husk, rice husk, and sand. The use of crumb rubber and other synthetic materials shall be prohibited in all applications except for sports fields.

(8) Artificial Turf shall not be treated as a fill in material, but rather as a planned element of the site or yard outside of required landscape areas and buffers

e. Installation, maintenance and repair.

(1) All artificial turf shall, at a minimum, be installed according to the manufacturer's specifications.

(2) All artificial turf installations shall be anchored to ensure that the turf will withstand the effects of wind.

(3) All seams shall be secured and edges shall be trimmed to fit against all regular and irregular edges to resemble a natural look.

(4) If artificial turf is planned to be installed immediately adjacent to a seawall, the artificial turf shall be pinned or staked behind the seawall. No artificial turf or installation mechanism shall be attached directly to or placed on a seawall or seawall cap.

(5) All artificial turf shall be installed over a subgrade prepared to provide positive drainage and an evenly graded mass of compacted, porous crushed rock aggregate material. Base comprising of sand only is not permitted. Proper drainage shall be provided for all Artificial Turf installations to prevent runoff or pooling of water.

(6) Artificial turf shall be visually level, with the grain pointing in a single direction.

(7) An appropriate solid barrier device (e.g., concrete mow strip, bender board or other barrier with a minimum of 38” thickness) is required to separate artificial turf from soil and live vegetation and to prevent intrusion of living plant material.

(8) Artificial turf shall not be installed directly against the trunk of trees and/or palms. A 3-foot mulch bed measured from the base of the tree or palm must be maintained around all tress and or palms. Precautions for installation around existing trees shall be monitored and may be restricted to ensure tree roots are not damaged with the installation of the base material and that the overall health of the tree will not be compromised.

(9) All artificial turf shall be maintained in a green fadeless condition and shall be maintained free of dirt, mud, stains, weeds, debris, tears, holes, and impressions. Maintenance shall include, but not be limited to cleaning, brushing, debris removal; repairing of depressions and ruts to maintain a visually-level surface; elimination of any odors, flat or matted areas, weeds, and invasive roots; and all edges of the artificial turf shall not be loose and must be maintained with appropriate edging or stakes.

(10) There shall be no parking on artificial turf.

(11) Artificial turf shall not be visible from public rights-of-way except where it is installed between parking strips or approved as part of a planned development.

(12) All other landscape requirements must be meet.

(13) Applicants shall provide an owner affidavit agreeing to perpetually maintain the artificial turf system in good working order to ensure that there is continued permeability. If the artificial turf falls into disrepair with fading or holes or loose areas. The replacement and/or repairs shall be done with like for like materials from the same manufacturer and done so in a manner that results in a repair that blends in with the existing artificial turf.

f. A landscape permit shall be obtained from the City prior to the installation of any artificial turf. The permit application shall include the following material specifications and plans.

(1) A landscape plan showing the area of synthetic turf, area of living plant material, and separation between these areas;

(2) A dimensioned cross section of proposed materials and installation details, including subgrade, drainage, base or leveling layer, and infill;

(3) Edge material and detail for seams;

(4) Material description and specifications, including manufacturer,

(5) Installer (with contact information), and warranty information.

(6) A sample of the artificial turf proposed that meets these standards.

(7) Product specifications that demonstrate compliance the requirements for artificial turf in this article and the ability to be warrantied in the United States of America.

(8) The plan shall demonstrate conformance with the City's landscape requirements.

g. A Certificate of Appropriateness shall be obtained from the HRPB prior to the installation of any artificial turf in a historic district.

h. Inspections. An in-progress inspection shall be required to ensure that the appropriate base material has been installed in accordance to the manufactures' specifications. A final inspection shall also be required.

Summary

- Exhibit G: Article 6 - Section 23.6-1 – Landscape Regulations (Artificial Turf)
  - The proposed amendments would allow for artificial turf within the City subject to the requirements related to location, quality and installation.

CITY OF LAKE WORTH BEACH
Community Sustainability℠

Pros/Cons Artificial Turf:

Pros	Cons
Maintains Color and Appearance Year Round	Can be damaged and torn or worn down with heavy foot traffic over time
Not Damage by Pests	50 to 100 degrees hotter than ambient air temperature
May be lower maintenance than traditional sod applications. No fertilizer or pest control treatments.	Regular washing and raking of the product is necessary to mitigate the accumulation dirt and odor from leaves, pet hair and animal waste
New less toxic products are on the market and alternate fill is available to crumb rubber.	Some products can leach into soils and there are concerns about water run-off from crumb rubber infill which might be harmful to families, pets, or the environment.
Some products are made from recycled materials	Artificial turf is not recyclable
Semi-pervious surface when correctly installed	Is not a fully pervious surface as soil or landscaping. Incorrectly installed material may pool water.

Summary

- <u>Exhibit G</u>: Article 6 - Section 23.6-1 – Landscape Regulations (Artificial Turf)

  - Where should it be allowed?
  - How should it be maintained and permitted?
  - What quality of material should be required?

Summary

- Exhibit G: Article 6 - Section 23.6-1 – Landscape Regulations (Artificial Turf)

- Where
  - Single family and duplex properties in the rear yard only and not visible from the right of way.
  - Between parking strips in the front yard of non-conforming properties previously constructed with off-street parking utilizing sixty percent (60%) or more of the width of the front yard. This application of artificial turf shall be approved by the Development Review Official or applicable review board, which shall review the proposed application for consistency with the City's land development regulations, visual appropriateness, enhanced site design and appearance, and improved drainage. Properties located in historic districts will require a Certificate of Appropriateness from the HRPB.
  - On roof top terraces.
  - As part of a planned development in a recreation or amenity area.

  - Artificial turf shall **not** be installed:
    (1) as part of any landscape buffer or landscape area required by this article;
    (2) within permanent drainage features (e.g., ponds, swales); or
    (3) in any public right of way.

Summary

- Exhibit G: Article 6 - Section 23.6-1 – Landscape Regulations (Artificial Turf)

- How
  - Landscape permit is required with 2 inspections
  - Affidavit of maintenance is required
  - Barrier is required between the artificial turf and landscaping
  - Subsurface material specifications, crumb rubber is not permitted

- What
  - Minimum quality standards
    - Test documentation which declares that the artificial turf yarn and backing materials are disposable under normal conditions, at any U.S. landfill station (Total Content Leach Protocol (TCLP) test).
  - Appearance standards
    - Artificial turf shall consist of green lifelike individual blades of grass that emulate natural turf in look and color and shall have a minimum pile height of one- and one-half inches and shall have a minimum tufted weight of 80 ounces per square yard.
  - 10 Year Warranty
  - Drainage standards

Summary

- Exhibit G: Article 6 - Section 23.6-1 – Landscape Regulations (Artificial Turf)
  - Board Discussion

Attachment B: Rock Yards & Mulch

The City's Landscape Ordinance section 23.6-1 requires the implementation of Florida-Friendly Landscaping Principles, which are 9 science-based principles for sustainable landscapes. These principles were developed by the University of Florida's IFAS and are the foundation of the University's Florida Friendly Landscaping Program. While rock as mulch or rock yards are installed in the region by some homeowners, they are not considered to be Florida-Friendly by the University, and are discouraged for the following reasons within the City:

- Rocks increase heat on plants, especially plants' roots, which can stress plants. This heat stress causes dehydration and affects plant growth and development. (UF IFAS Extension, 2023 & Zhao, J., Lu, Z., Wang, L., & Jin, B., 2020)
- Rocks do not support Florida's wildlife, including bees, butterflies, birds and animals as the removal of trees and landscaping can result "in loss of habitat, or in habitat that does not support wildlife." (UF IFAS, 2023)
- According to the US EPA, "trees and other plants help cool the environment, making vegetation a simple and effective way to reduce urban heat islands." (US EPA, 2023)
- Xeriscape yards, which typically use rocks with very few plants or none at all, have a higher water runoff rate than yards with sod or plant material. (Simpson, T. J., and R. A. Francis. 2021)
- Even with a weed barrier, weeds will still grow and will need to be pulled or treated with herbicide.
- Leaves and other organic matter will not properly decompose, which will cause the rock to be unsightly without maintenance.

<u>Acceptable uses of rock consistent with the UF IFAS Florida-Friendly Program:</u>

- Smaller rocks such as pea gravel or crushed rock are great for walkways in single-family/two-family properties. Broad flat rocks like flagstone in lieu of concrete stepping stones for added attraction.
- Medium-sized rocks can be arranged to create edging around landscape beds.
- Large rocks can be used as art. Set on their own in landscape beds they make great sculptural accents.
- Placed under roof overhangs to lessen the effects of rainfall.
- Used in rain gardens or in wet, slow draining areas.

A good alternative to rocked yards is a thick layer of organic mulch planted with shrubs and groundcovers. Proper plant selection and placement will create an attractive landscape that will require minimal irrigation and maintenance.

(UF IFAS, 2023)

References:

University of Florida IFAS Extension. (March 2023). *Florida-Friendly Landscaping Program.* https://ffl.ifas.ufl.edu/about-ffl/

U.S. Environmental Protection Agency. (March 2023). *Heat Islands – Using trees and vegetation to reduce heat islands*. https://www.epa.gov/heatislands/using-trees-and-vegetation-reduce-heat-islands

Simpson, T. J., and R. A. Francis. (2021). "Artificial Lawns Exhibit Increased Runoff and Decreased Water Retention Compared to Living Lawns Following Controlled Rainfall Experiments." *Urban Forestry & Urban Greening* 63:127232. https://doi.org/10.1016/j.ufug.2021.127232

Zhao, J., Lu, Z., Wang, L., & Jin, B. (2020). Plant Responses to Heat Stress: Physiology, Transcription, Noncoding RNAs, and Epigenetics. *International journal of molecular sciences*, *22*(1), 117. https://doi.org/10.3390/ijms22010117

The City of Lake Worth Tree Board
City Hall Conference Room
Regular Meeting Minutes
March 16, 2023

Call to order: 6:15

Members Present: D. Kerner, G. Powell, D. Brown and G. Timor

Members Absent: None

Agenda additions, deletions, reordering: None

Public Attendance: None

Approval of minutes: Tabled to next meeting

Reports: G. Powell provided a report on the Beach landscape inspection and report. She also informed the board that she met with the City Horticulturist at the beach property to map the invasive plants that are in the dune. The beach report will be provided to the board.

New Business:

A. Artificial turf, rock and mulch

1. The Board reviewed the previously disapproved artificial turf ordinance and discussed the pros and cons of allowing artificial turf to be installed.

   Motion made by D. Brown and seconded by G. Timor to prohibit artificial turf in the City of lake Worth Beach.

   Prior to the vote the board discussed adding language to the ordinance stating that Artificial turf is prohibited.

   Amended motion made by D. Brown and seconded by G. Timor to prohibit artificial turf in the City of lake Worth Beach and to add language to the ordinance that- Artificial turf is prohibited.

   AYES: D. Kerner, G. Timor, and D. Brown.

   NAYS: G. Powell

   Motion carries.

2. The Board then discussed code section 23.6.1 (c) (1) (e) -All other lots areas not covered by driveway or structures shall be planted with living groundcover or other approved materials.

   Motion made by G. Powell and seconded by G. Timor that a sentence be added to the end this section – See section K for other approved materials.

   AYES: D. Kerner, G. Powell, D. Brown and G. Timor

   Nays: None

3. The Board discussed code section 23.6-1 (k) (10) Groundcovers

Motion made by G. Timor and seconded by G. Powell to change the word ~~turf~~ to grass and to strike the last sentence-~~All groundcover areas must be kept free from weeds.~~

AYES: D. Kerner, G. Powell, D. Brown and G. Timor

NAYS: None

4. The Board discussed code section 23.6-1 (K) (12) Organic Mulches
   G. Timor made a motion to add to the following sentence - No more than fifty (50) percent of a front or side street setback or yard may be comprised of mulch independent of living plant materials. Including but not limited to shrubs, shrubs and groundcovers. Trees and palms shall not count towards this requirement.

5. The Board discussed code section 23.6-1 (K) (12) Organic Mulches
   Motion made by G. Powell and seconded by D. Brown to combine the organic and inorganic code sections in to one section with the same plant requirements.

   AYES: D. Kerner, G. Powell, D. Brown and G. Timor

   NAYS: None

Old Business: Tabled to next regular meeting

Adjourned: 7:50 PM

Florida Statute 166.048 Conservation of Water; Florida-Friendly Landscaping (Title VII Municipalities)

Link to source

166.048 Conservation of water; Florida-friendly landscaping.—

(1)(a) The Legislature finds that Florida-friendly landscaping contributes to the conservation, protection, and restoration of water. In an effort to meet the water needs of this state in a manner that will supply adequate and dependable supplies of water where needed, it is the intent of the Legislature that Florida-friendly landscaping be an essential part of water conservation and water quality protection and restoration planning.

(b) As used in this section, "Florida-friendly landscaping" has the same meaning as in s. 373.185.

(2) The governing body of each municipality shall consider enacting ordinances, consistent with s. 373.185, requiring the use of Florida-friendly landscaping as a water conservation or water quality protection or restoration measure. If the governing body determines that such landscaping would be of significant benefit as a water conservation or water quality protection or restoration measure, especially for waters designated as impaired pursuant to s. 403.067, relative to the cost to implement Florida-friendly landscaping in its area of jurisdiction in the municipality, the governing body shall enact a Florida-friendly landscaping ordinance. Further, the governing body shall consider promoting Florida-friendly landscaping as a water conservation or water quality protection or restoration measure by: using such landscaping in any areas under its jurisdiction which are landscaped after the effective date of this act; providing public education on Florida-friendly landscaping, its uses in increasing water conservation and water quality protection or restoration, and its long-term cost-effectiveness; and offering incentives to local residents and businesses to implement Florida-friendly landscaping.

(3)(a) The Legislature finds that the use of Florida-friendly landscaping and other water use and pollution prevention measures to conserve or protect the state's water resources serves a compelling public interest and that the participation of homeowners' associations and local governments is essential to the state's efforts in water conservation and water quality protection and restoration.

(b) A deed restriction or covenant may not prohibit or be enforced so as to prohibit any property owner from implementing Florida-friendly landscaping on his or her land or create any requirement or limitation in conflict with any provision of part II of chapter 373 or a water shortage order, other order, consumptive use permit, or rule adopted or issued pursuant to part II of chapter 373.

(c) A local government ordinance may not prohibit or be enforced so as to prohibit any property owner from implementing Florida-friendly landscaping on his or her land.

History.—s. 6, ch. 91-41; s. 6, ch. 91-68; s. 3, ch. 2001-252; s. 22, ch. 2009-243.

Florida Statute 373.185 Local Florida-Friendly Landscaping Ordinances (Title XXVIII Natural Resources; Conservation, Reclamation, and Use)

Link to source

373.185 Local Florida-friendly landscaping ordinances.—

(1) As used in this section, the term:

(a) "Local government" means any county or municipality of the state.

(b) "Florida-friendly landscaping" means quality landscapes that conserve water, protect the environment, are adaptable to local conditions, and are drought tolerant. The principles of such landscaping include planting the right plant in the right place, efficient watering, appropriate fertilization, mulching, attraction of wildlife, responsible management of yard pests, recycling yard waste, reduction of stormwater runoff, and waterfront protection. Additional components include practices such as landscape planning and design, soil analysis, the appropriate use of solid waste compost, minimizing the use of irrigation, and proper maintenance.

(2) Each water management district shall design and implement an incentive program to encourage all local governments within its district to adopt new ordinances or amend existing ordinances to require Florida-friendly landscaping for development permitted after the effective date of the new ordinance or amendment. Each district shall assist the local governments within its jurisdiction by providing a model Florida-friendly landscaping ordinance and other technical assistance. Each district may develop its own model or use a model contained in the "Florida-Friendly Landscape Guidance Models for Ordinances, Covenants, and Restrictions" manual developed by the department. To qualify for a district's incentive program, a local government ordinance or amendment must include, at a minimum:

(a) Landscape design, installation, and maintenance standards that result in water conservation and water quality protection or restoration. Such standards must address the use of plant groupings, soil analysis including the promotion of the use of solid waste compost, efficient irrigation systems, and other water-conserving practices.

(b) Identification of prohibited invasive exotic plant species consistent with s. 581.091.

(c) Identification of controlled plant species, accompanied by the conditions under which such plants may be used.

(d) A provision specifying the maximum percentage of irrigated turf and impervious surfaces allowed in a Florida-friendly landscaped area and addressing the practical selection and installation of turf.

(e) Specific standards for land clearing and requirements for the preservation of existing native vegetation.

(f) A monitoring program for ordinance implementation and compliance.

(3) Each water management district shall also work with the department, local governments, county extension agents or offices, nursery and landscape industry groups, and other interested stakeholders to promote, through educational programs, publications, and other district activities authorized under this chapter, the use of Florida-friendly landscaping practices, including the use of solid waste compost, in residential and commercial development. In conducting these activities, each district shall use the materials developed by the department, the Institute of Food and Agricultural Sciences at the University of Florida, and the Center for Landscape Conservation and Ecology Florida-Friendly Landscaping Program, including, but not limited to, the Florida Yards and Neighborhoods Program for homeowners, the Florida Yards and Neighborhoods Builder Developer Program for developers, and the Green Industries Best Management Practices Program for landscaping professionals. Each district may develop supplemental materials as appropriate to address the physical and natural characteristics of the district. The districts shall coordinate with the department and the Institute of Food and Agricultural Sciences at the University of Florida if revisions to the educational materials are needed.

(a) The Legislature finds that the use of Florida-friendly landscaping and other water use and pollution prevention measures to conserve or protect the state's water resources serves a compelling public interest and that the participation of homeowners' associations and local governments is essential to the state's efforts in water conservation and water quality protection and restoration.

(b) A deed restriction or covenant may not prohibit or be enforced so as to prohibit any property owner from implementing Florida-friendly landscaping on his or her land or create any requirement or limitation in conflict with any provision of part II of this chapter or a water shortage order, other order, consumptive use permit, or rule adopted or issued pursuant to part II of this chapter.

(c) A local government ordinance may not prohibit or be enforced so as to prohibit any property owner from implementing Florida-friendly landscaping on his or her land.

(4) This section does not limit the authority of the department or the water management districts to require Florida-friendly landscaping ordinances or practices as a condition of any permit issued under this chapter.

History.—s. 3, ch. 91-41; s. 3, ch. 91-68; s. 7, ch. 2001-252; s. 17, ch. 2009-243.

Florida Statute 373.187 Water Management District Implementation of Florida-Friendly Landscaping (Title XXVIII Natural Resources; Conservation, Reclamation, and Use)

Link to source

373.187 Water management district implementation of Florida-friendly landscaping.—Each water management district shall use Florida-friendly landscaping, as defined in s. 373.185, on public property associated with buildings and facilities owned by the district and constructed after June 30, 2009. Each district shall also develop a 5-year program for phasing in the use of Florida-friendly landscaping on public property associated with buildings or facilities owned by the district and constructed before July 1, 2009.

History.—s. 18, ch. 2009-243.

UF IFAS Extension UNIVERSITY of FLORIDA

UF/IFAS PEER REVIEWED ENH1348

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Synthetic Turfgrass and the Nine Principles of Florida-Friendly Landscaping™[1]

Jason Kruse, Bryan Unruh, Jennifer Marvin, Tom Wichman, Lynn Barber, Norma Samuel, John Bossart, Claire Lewis, and Esen Momol[2]

Introduction

Homeowners in Florida are offered many different species and cultivars of natural turfgrass to consider for their lawns, each offering varying levels of shade, maintenance, water, disease, and pest resistance, as well as differences in color, texture, and overall aesthetics. Recent additions to the list of available turfgrasses have benefited from extensive breeding programs to develop cultivars that need fewer inputs (e.g., water and fertilizer), have fewer pest problems, and require less mowing, all traits that contribute to their appropriate use in Florida-Friendly Landscaping™ (FFL) (Momol et al. 2021).

However, in addition to these living turf options, some homeowners replace natural turfgrass with synthetic turf, also referred to as artificial turf. Originally developed as a durable, low-maintenance playground surface, synthetic turf is a manufactured product that utilizes synthetic fibers that mimic the aesthetic look of natural grass. Essentially outdoor carpet, artificial turf is typically composed of nylon, polypropylene, or polyethylene fibers connected to a reinforced backing material. While designed to imitate the look of natural turf, synthetic turf does not provide the ecosystem benefits of a natural turf system. This publication examines the properties of synthetic turf in relation to each of FFL's nine principles.

Florida-Friendly Landscaping™: The Nine Program Principles

FFL protects Florida's natural resources by conserving water, reducing waste and pollution, creating wildlife habitat, and preventing runoff and erosion (Momol et al. 2021). Landscapes in Florida can be Florida-Friendly if designed and maintained according to the nine Florida-Friendly Landscaping™ principles (FYN Handbook 2015). Each of the nine Florida-Friendly Landscaping™ principles are evaluated below as they relate to living turfgrass and its potential replacement by synthetic turf.

1. **Right Plant, Right Place**: FFL's mission is to provide science-based information for creating resilient, sustainable landscapes of living plants that have been specifically selected and appropriately installed so that they require little or no irrigation, fertilizer, or pesticide. Because synthetic turf is not alive, it does not meet the criteria

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2. Jason Kruse, associate professor, Environmental Horticulture Department; Bryan Unruh, professor and associate center director, Environmental Horticulture Department, UF/IFAS West Florida Research and Education Center, Jay, FL; Jennifer Marvin, statewide FYN coordinator, UF/IFAS Florida-Friendly Landscaping™ Program; Tom Wichman, assistant director and statewide GI-BMP coordinator, UF/IFAS Florida-Friendly Landscaping™ Program, UF/IFAS Center for Land Use Efficiency; Lynn Barber, program county Extension agent II, Florida Friendly Landscaping™, UF/IFAS Extension Hillsborough County; Norma Samuel, Extension agent IV, PhD, Florida Friendly Landscaping™ and urban horticulture, UF/IFAS Extension Sumter County; John Bossart, Extension program manager, UF/IFAS Florida-Friendly Landscaping™ Program; Claire Lewis, statewide FFC coordinator, UF/IFAS Florida-Friendly Landscaping™ Program; and Esen Momol, director, UF/IFAS Florida-Friendly Landscaping™ Program; UF/IFAS Extension, Gainesville, FL 32611.

of a plant choice for an FFL landscape. As a living plant, natural turfgrass plays an important role in cooling the environment that synthetic turf cannot. Average surface temperatures of a natural turfgrass lawn have been reported to be as much as 70°F cooler than a dormant brown lawn and as much as 100°F cooler than synthetic turf surfaces. Higher surface temperatures increase the surrounding air temperatures and result in an increase in the energy required for mechanical cooling of adjacent homes and buildings. Caludio (2008) describes heat island effects generated by larger installations of synthetic turf. Living turfgrass also provides a root zone, which helps to filter and slow runoff and stop erosion. Synthetic turf cannot do this, because part of its installation requires compacting the earth below, increasing runoff beneath the synthetic turf.

2. **Water Efficiently**: Synthetic turf systems do not require supplemental irrigation; however, installations may require water use for different reasons. As mentioned above, synthetic turf can become excessively hot, with one author (Kruse) measuring surface temperatures on synthetic turf as high as 160°F. Because of these high temperatures, it is common for users to spray the surface with water to cool it for use, which may negate some of the perceived benefit from the system not requiring "irrigation." In addition, many manufacturers recommend weekly wash downs of the artificial turf surface to remove contaminants such as dust and pet waste and its odor. These washings, especially those to remove pet urine, often use quite a bit of water because the waste must pass through the artificial turf, the underlying substrate, and the weed barrier before being carried away. This wash water will generally not infiltrate into the ground below because of soil compaction conducted before installation of the synthetic turf. As noted in *The Ultimate Artificial Grass Maintenance Guide* (neograss.co.uk):

   > If your lawn has not been installed on a free-draining sub-base, then you may need to purchase one of the many artificial grass cleaning products available on the market that will remove the smell of urine and sanitize your lawn.

   Living turf, on the other hand, helps cool the environment, absorbs pet urine, and does not require washing to remove odors or dust. Once established, living turf needs minimal water during times of drought.

3. **Fertilize Appropriately**: Synthetic turf systems do not require fertilization. However, the lack of a root system and its associated microbial community in synthetic turf systems eliminates the water filtration benefit that is gained through the installation of a living turfgrass system.

4. **Mulch:** In an FFL landscape, mulch is often incorporated within ornamental beds and around shrubs to maintain soil moisture and control weed growth. However, mulch application is not applicable to synthetic turf systems.

5. **Attract Wildlife:** An FFL landscape will often incorporate elements that attract wildlife, including the installation of host and pollinator plants to attract butterflies and native bees, as well as mixes of shrubs and trees that provide food, cover, and nesting opportunities for birds and other wildlife. This effect is amplified when natural wildlife preserves, and other green areas are adjacent or nearby. Research has shown that turfgrass lawns support an abundance of beneficial arthropods, such as beetles, bees and wasps, as well as worms, which in turn support larger wildlife such as birds and other ground-feeding wildlife (Shimat et al. 2020). Synthetic turf does not offer any benefits that attract or support wildlife.

6. **Manage Yard Pests Responsibly:** A fundamental component of FFL is using the appropriate combinations of plants (see FFL Principle No. 1: Right Plant, Right Place) maintained through proper irrigation and fertilizer protocols, so that yard pests are controlled with little or even no need for pesticide application. This holistic pest management approach forms the basis of integrated pest management, or IPM. As discussed above, while synthetic turf plays no role in attracting or supporting wildlife, it also does not contribute to the mix and balance of landscaping plants that promote IPM.

7. **Recycle Yard Waste:** FFL promotes the recycling of yard and landscape clippings into mulch and compost. This not only reduces the amount of yard waste that must be picked up curbside and transported for disposal, but yard waste converted to compost and used as fertilizer decreases the need for a homeowner to buy other fertilizers, especially synthetic fertilizers. Because synthetic turf is primarily plastic, it does not directly generate yard waste such as leaf litter and clippings, although falling leaves that accumulate on the synthetic turf must still be removed to prevent wear and tear. More importantly, however, synthetic turf has a finite life span, perhaps 10 to 20 years depending on the quality of ongoing care including rinsing, removing leaves, and sanitizing. At the end of its life, the synthetic turf will need to be removed and replaced, with the ultimate disposal of the old synthetic turf most likely in a landfill.

8. **Reduce Stormwater Runoff:** The primary base construction for synthetic turf systems in residential landscapes involves removal of a portion (2"–3") of the topsoil followed by heavy compaction of the remaining soil to establish a firm, uniform base on which to install the synthetic turf product. This compaction reduces soil infiltration rates and increases the risk of runoff from the landscape. While it may be possible to use rain gardens, berms, and swales to retain runoff on the property, there remains a significant risk of increased runoff when compared to natural turfgrass, which has been shown to increase soil infiltration rates. A recent study by Simpson and Francis (2021) demonstrated that synthetic turf lawns had more runoff and decreased water retention compared to living turf lawns. A similar study (Chang et al. 2021) found that living turf provided greater runoff control than synthetic turf.

    a. In addition to runoff volume, synthetic turf runoff has been shown to contain zinc in concentrations that pose a potential risk to surface waters and aquatic organisms (Connecticut Department of Environmental Protection 2010). Another synthetic turf study in New York found that runoff water from rain or from spraying or misting contained some 25 different chemical species and four metals (zinc, selenium, lead, and cadmium) that were released into water from the rubber infill incorporated into the synthetic turf (Claudio 2008).

    b. In contrast to synthetic turf, a healthy, established natural turf system consists not only of the dense cover of the aboveground grass blades, but also an underlying deep, intricately intertwined root zone that can filter and absorb contaminants. Natural turf installations improve soil structure over time and as a result enhance water filtration and infiltration into the soil. A robust root zone with healthy soil will also absorb dissolved nutrients, decrease nutrient leaching into the underlying ground water, and sequester carbon. Because, by definition, synthetic turf systems do not consist of plant material, they have no capacity to provide these same ecosystem services as a living turf.

9. **Protect the Waterfront**: Synthetic turf systems lack the soil-stabilizing benefits offered by the rootzones of flood-tolerant plants that are typically found along the edges of water bodies. The presence of these plants protects the shoreline from erosion and has been documented as having a significant impact in reducing the concentration and amount of contaminates that enter bodies of water through stormwater runoff. Installation of a synthetic turf system along the edge of a water body increases the risk of soil erosion due to the lack of an established soil-stabilizing rootzone. In addition, the increased risk of runoff due to compaction of the soils during installation will increase the risk of pollutants reaching the water body that may have otherwise been caught/filtered out by the natural turfgrass system.

Conclusions

Protecting and preserving Florida's water resources through sustainable landscaping practices on living landscapes is the primary focus of the Florida-Friendly Landscaping™Program. It strives to achieve this goal through implementation of nine principles designed to reduce the environmental impact of urban landscapes while creating wildlife habitat, preventing erosion, and reducing landscape-based contributions to landfills. When considering the use of a synthetic turf system in the urban landscape, it is important to understand all the potential environmental impacts. Synthetic turf systems have not been shown to improve or create wildlife habitat, do not improve groundwater recharge, can heat excessively in the sun and, in more extensive installations, can cause a substantial heat island effect. In addition, synthetic turf generates higher stormwater runoff than natural turf and has been shown to leach a variety of contaminants, including both organic compounds and heavy metals. Finally, since synthetic turf is primarily plastic it has a finite lifespan and must eventually be disposed of in a landfill, a practice that is counter to the sustainability goals of the Florida-Friendly Landscaping™ Program.

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Effects of urban residential landscape composition on surface runoff generation

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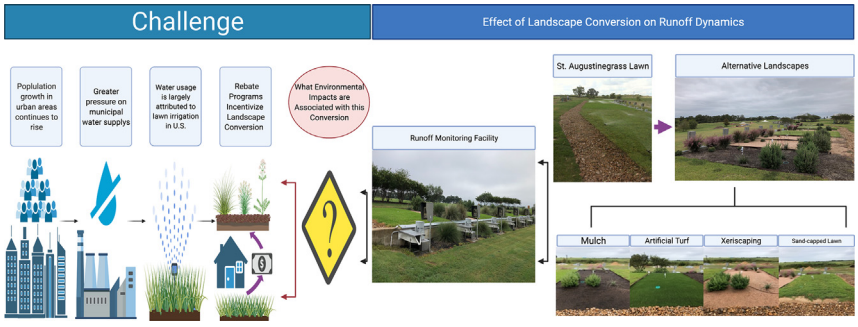
HIGHLIGHTS

- Pressure to save water has caused a shift from lawns to water-efficient landscapes.
- Runoff volumes were affected by landscape, rainfall, and age of the landscape.
- Grass lawns showed greater runoff control than artificial turf and xeriscaping.
- Sand-capped lawn further enhanced control of runoff.

GRAPHICAL ABSTRACT



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ABSTRACT

Lawns have long been a primary feature of residential landscapes in the United States. However, as population growth in urban areas continues to rise, water conservation is becoming a key priority for many municipalities. In recent years, some municipalities have begun to offer rebate programs which incentivize removal of turfgrass areas and conversion to alternative 'water-efficient' landscapes, with the goal of reducing outdoor water use. The environmental impacts and changes to ecosystem services associated with such landscape alterations are not well understood. Therefore, a 2-year continuous research project was conducted at the Urban Landscape Runoff Research Facility at Texas A&M University to evaluate rainfall capture and runoff volumes associated with several commonly used residential landscape types (including, St. Augustine grass Lawn, Xeriscaping, Mulch, Artificial Turf, and Sand-capped Lawn) and to characterize the flow dynamics of surface runoff in relation to rainfall intensity for each landscape. The results demonstrate that runoff dynamics differ between landscapes, but also change over time as the newly converted landscapes become established. Following the initial months of establishment, the effects of landscape type on runoff volumes were significant, with Artificial Turf and Xeriscaping generating greater runoff volumes than Mulch and St. Augustine grass Lawns for most runoff events, which is partially due to the low infiltration rate of such landscapes. Overall, Artificial Turf and Xeriscaping showed the greatest cumulative runoff volumes (>400 L m^{-2}), whereas Water Efficient- Mulch, Sand-capped Lawn and St. Augustine grass Lawn had a significantly lower cumulative runoff volumes, ranging from 180 to 290 L m^{-2}. Information from this research should be useful to municipalities, water purveyors, and homeowner associations as they weigh the long-term hydrological impacts of lawn removal and landscape conversion programs.

1. Introduction

In modern western countries, such as the United States (U.S.), turfgrass lawns have long played an important role in urban landscapes, originally adopted from English pre-romantic gardening (Jackson,

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1985). Turfgrasses in a traditional European-style garden are generally an element of the entire garden, planted along with other ornamental plants, such as flowers and trees (Jenkins, 1994). The use of turfgrass lawns within the American landscape has increased tremendously since the mid-20th century, primarily through the expansion of the monoculture of lawn (Robbins and Birkenholtz, 2003). While turfgrass lawns are a smaller component of the European garden, they have become a major component of residential landscapes in the U.S. (Jenkins, 1994). U.S. turfgrass acreage has been estimated to be 163,800 km^2, which is three times larger than any irrigated crop (Milesi et al., 2005). As rapid population growth continues in urban areas, water conservation has become a key priority for many municipalities. According to the World Health Organization (WHO), more than 50% of the world's population now lives in urban towns and cities, up from 34% in 1960. This trend towards greater urbanization is expected to continue at a rate of 1.63% per year between 2020 and 2025, and 1.44% per year between 2025 and 2030 (WHO, 2020).

If the amount of irrigated urban green space continues to grow as urbanization continues, it will place increasing strains on water supplies. More than 50% of domestic water usage is allocated to residential landscape irrigation in many areas of the world, including parts of the U.S. (Mayer et al., 1999; Degen, 2007; Haley et al., 2007). In Texas alone, Cabrera et al. (2013) estimated the combined sum of water use by golf courses and landscapes to be 46.6% of total water use within the urban/municipal water sector and 12.6% of the total annual demand by all activities during 2010, making urban irrigation the state's third largest water user behind agricultural irrigation and other urban uses. Of this total, the authors estimated annual water use on landscapes to range from 1.898 million to 4.021 million acre-feet, with golf course water use estimated at 0.364 million acre-feet.

While homeowners have traditionally installed and appreciated landscapes comprised predominantly of turfgrass; in recent years some municipalities have begun to offer rebate programs incentivizing removal of turfgrass areas and conversion to alternative landscapes thought to be more water-efficient (Addink, 2005; Zhang and Khachatryan, 2018; Chesnutt, 2019; Pincetl et al., 2019). For example, the 'cash for grass' rebate program developed by North Martin Water District, CA offered residential customers rebates of up to \$50 per 100 ft^2 (9.3 m^2) of lawn to remove irrigated grass from the landscape and replace it with approved, low water-use plants (Chesnutt, 2019). As a component of these programs, homeowners are often required to adopt specific landscape designs and planting materials, presumably those with good adaptation to the region. Typical restrictions of these rebate programs include no turf-to-turf conversion, use of smart irrigation installation, and less than 50% overall grassed area within the final landscape (Wilkinson et al., 2013; Zhang and Khachatryan, 2018).

One of the most popular water-efficient landscapes in the southwestern U.S. is xeriscaping, which involves installation of native plants requiring little to no water to supplement precipitation (Mustafa et al., 2010). Studies to estimate the overall water savings from water-efficient landscape conversions have been conducted in recent years. For example, Chesnutt (2019) evaluated changes in water consumption of landscape owners who participated in landscape conversion programs and reported water savings of 2897 L m^{-2} to 3317 L m^{-2} for the first and tenth year following conversion, respectively. Wade et al. (2010) estimated at least \$60 per year could be saved on water and sewage costs following conversion of 93 m^2 irrigated to non-irrigated landscape. While water-efficient landscape conversions offer potential to reduce outdoor water use, long-term environmental impacts and ecosystem services associated with these landscape changes following lawn removal are not well understood and are often overlooked. Natural grass lawns provide many benefits both to the environment and to humans, such as temperature mitigation, carbon sequestration, noise reduction, air pollution control, and glare reduction (Beard and Green, 1994; Bolund and Hunhammar, 1999; Monteiro, 2017).

Surface runoff is an important component of the hydrological system of urban areas, and to which stormwater and irrigation water contributes. The effects of urbanization and associated land cover alteration on surface runoff have been widely documented, with more frequent and greater hydrological issues such as stream channel erosion and flooding occurring in recent years, especially for coastal areas (Holman-Dodds et al., 2003; Olivera and DeFee, 2007; Woltemade, 2010). However, most studies of this type have primarily evaluated surface runoff effects occurring from land disturbance, for example, comparing native landscapes to developed areas (Arnold and Gibbons, 1996; Holman-Dodds et al., 2003; Olivera and DeFee, 2007; Guzha et al., 2018; Wang and Stephenson, 2018; Lacher et al., 2019; Gao et al., 2020). Few studies have sought to directly compare ecosystem services between different types of residential landscapes.

To better understand the hydrological impact from landscape conversion, information on rainfall capture and surface runoff dynamics of different urban landscapes is needed. The hypothesis of this study was that runoff generation and patterns should be different for different urban landscapes. Therefore, the objectives of this study were to evaluate the total rainfall capture and runoff volumes generated during natural rainfall events from several commonly used residential landscape types and to characterize the flow dynamics and peak flow of surface runoff in relation to rainfall intensity for each landscape.

2. Material and methods

2.1. Study site

This study was conducted at the Urban Landscape Runoff Facility located at the Texas A&M University Soil and Crop Sciences Field Research Laboratory, College Station, TX from August 2018 to August 2020. The facility comprises 24 individually irrigated 4.1 m × 8.2 m research plots originally established in 2012 with 'Raleigh' St. Augustine grass atop a Boonville fine sandy loam soil (fine, smectitic, thermic, chromic vertic Albaqualf). All plots were constructed to a final slope of 3.7 ± 0.5%, which was intended to preserve the existing native soil profile and slope of the site with minimal disturbance. Each plot was equipped with its own irrigation control and runoff collection system. Runoff was intercepted at the base of each plot by a gutter drain which flowed into a 23 cm H-shaped flume which was equipped with an ISCO bubbler flow meter (ISCO 4230, Teledyne Isco, Lincoln NE) and auto-sampler (ISCO 6712, Teledyne Isco, Lincoln NE). For a complete description of the facility, refer to Wherley et al., 2014. The setup allowed for full documentation of the runoff dynamics including flow patterns and runoff water volumes from irrigation and rainfall events.

2.2. Experimental design

To initiate this study, renovation of some of the grass plots to various types of assumably more water-efficient landscape plots was completed during August 2018, according to a design and native plant selection recommended by a professional landscape architect in the region (personal communication). Due to limitations on number of available plots for use in the research, the study was conducted as an unbalanced randomized complete block design. As there was a difference in the depth of native soil across the study site (25 to 41 cm), which could have an effect on runoff, plots with similar depth were grouped into blocks. Four replications were included for St. Augustine grass Lawn, Mulch, and Xeriscaping, while three replications were included for Sand-Capped Lawn and Artificial Turf, respectively (Fig. 1). Following were the details of five landscape treatments used in the study (Fig. 2):

1) St. Augustine grass Lawn (control): The originally established six-year-old 'Raleigh' St. Augustine grass (*Stenotaphrum secundatum* (Walt.) Kuntze) established from sod atop of native fine sandy-loam soil in 2012.

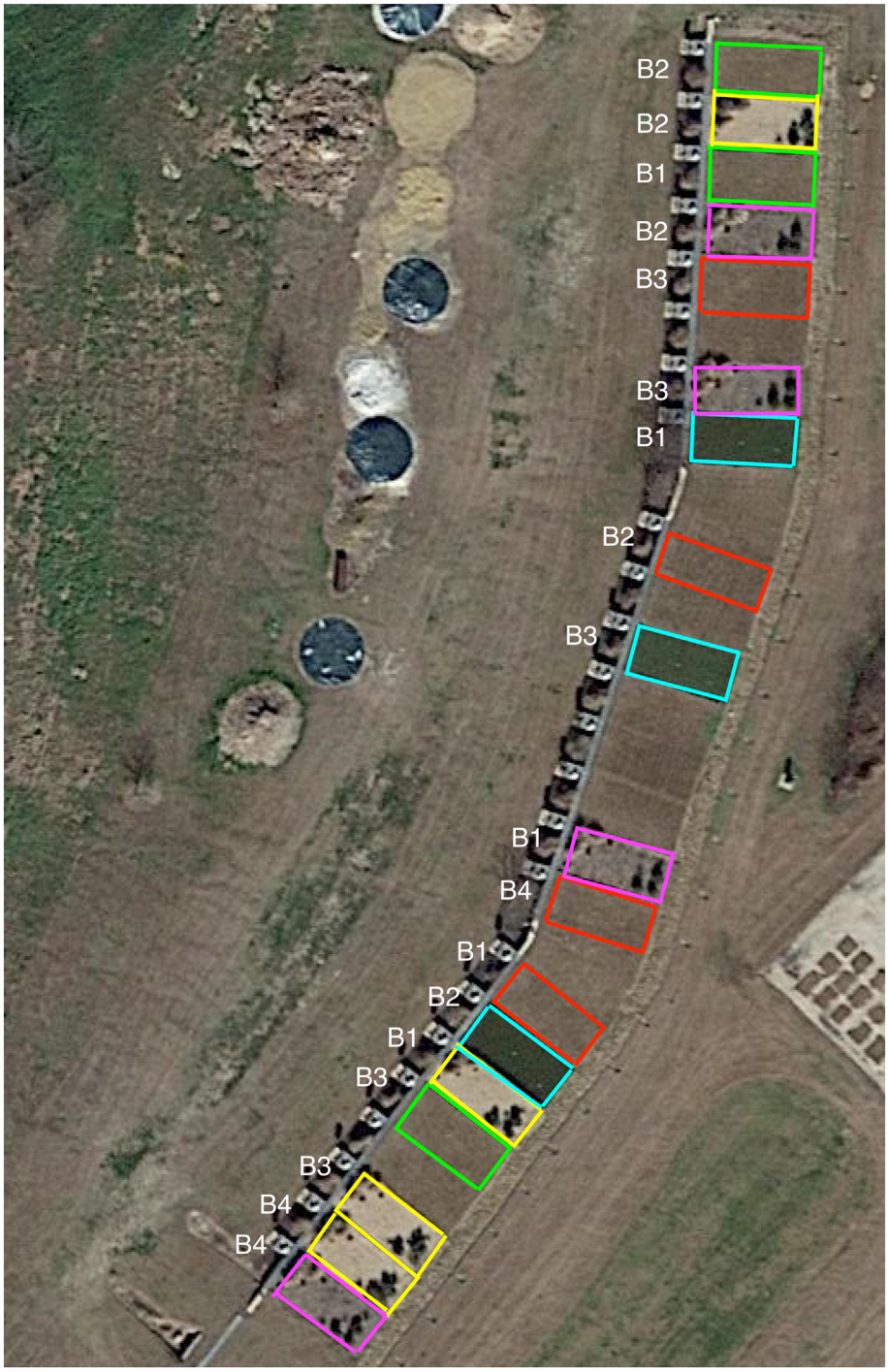

Fig. 1. Google satellite map of the Urban Landscape Runoff Facility located at the Soil and Crop Sciences Field Research Laboratory, at Texas A&M University, College Station, TX. The map was captured during winter. All Lawn plots show brown color due to dormancy. Green frames indicate Sand-capped Lawn. Red frames indicate St. Augustine grass Lawn. Blue frames indicate Artificial Turf. Yellow frames indicate Xeriscaping. Purple frames indicate Mulch. Few grassed plots were not included in this study. Blocks (B) were created based on the depth of topsoil and were highlighted with number (B1 (depth: 37–41 cm), B2 (depth: 34–36 cm), B3 (depth: 31–33 cm), and B4(depth: 25–30 cm)). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

2) Xeriscaping: Original St. Augustine grass sod and soil were stripped off to a depth of 7.5 cm using a sod cutter and removed. Locally adapted native plants including red yucca (*Hesperaloe parviflora*), Texas sage (*Leucophyllum frutescens*), muhly grass (*Muhlenbergia capillaris*), and dwarf yaupon holly (*Ilex vomitoria*) were then established into two 8.5 m^2 planting beds per plot. Prior to planting, each planting bed was first created by backfilling with 5 cm of the originally excavated soil. After planting, each bed was then covered with a 2.5 cm layer of compacted decomposed granite. The two planting beds occupied 50% of total plot area, which was chosen based on published minimal planted area requirements for several rebate programs (Austin Water, n.d. website; Valley Water, 2020 website). The remaining 50% of the excavated plot was covered with a 7.5 cm deep layer of compacted decomposed granite. When the landscape renovation was completed, no topsoil was visible, and a uniform decomposed granite layer covered the entire plot.
3) Mulch: Original St. Augustine grass sod and soil were stripped off to a depth of 2.5 cm (1 pass at 2.5 cm depth) using a sod cutter and

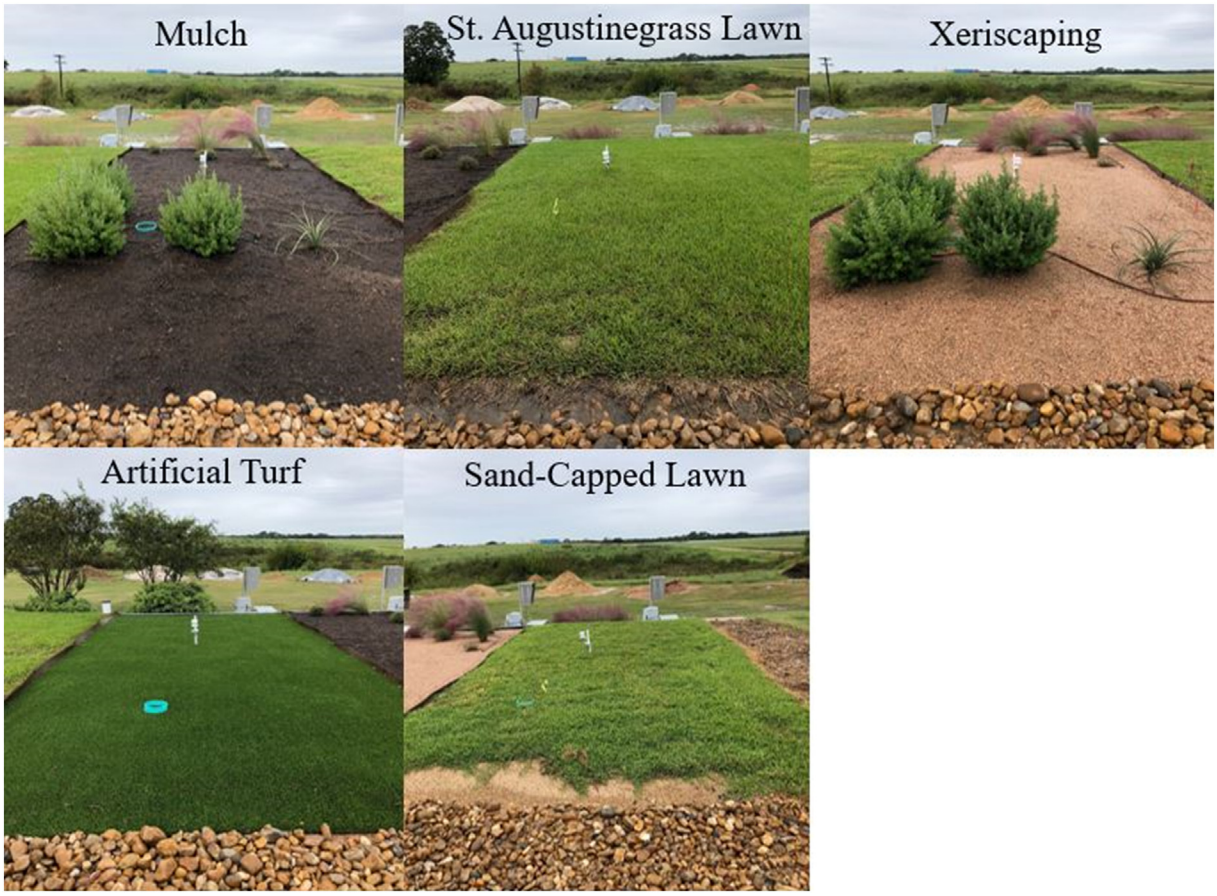

Fig. 2. Turfgrass Lawn and alternative 'water-efficient' landscape treatments tested at the Urban Landscape Runoff Facility at Texas A&M University. Photograph Credit Baoxin Chang August 2018.

removed. The same aforementioned arrangement of native species of water-efficient plants from the Xeriscaping treatment was used. After planting, a 5 cm layer of shredded hardwood mulch (New Earth Compost, San Antonio, TX) was uniformly spread over the entire plot.

4) Artificial Turf: Original St. Augustine grass sod and soil were stripped off to a depth of 7.5 cm using a sod cutter and removed. A 5 cm layer of compacted decomposed granite was uniformly applied to the entire plot. Premium II (EPS Turf, Ewing Landscape Materials, Phoenix, AZ) synthetic turf was then installed atop of compacted decomposed granite base. Green-dyed grit silica sand infill (Ewing Landscape Materials, Phoenix, AZ) was then incorporated into the base of the artificial turf at a rate of 9.76 kg m^{-2}.
5) Sand-Capped Lawn: Original St. Augustine grass sod and soil were stripped off to a depth of 2.5 cm using a sod cutter and removed. A 10 cm deep layer of medium-coarse concrete sand (Knife River Corp. Bryan, TX) was then placed overtop the native fine-sandy loam soil. Particle size analysis of the sand indicated the following mass fractions: 19.5% >2 mm, 7.4% within 1to 2 mm, 14.1% within 0.5 to 1 mm, 36.2% within 0.25 to 0.5 mm, 15.3% within 0.15 to 0.25 mm, and 4.5% <0.15 mm. Washed Raleigh St. Augustine grass sod was then laid atop of the 10 cm sand-cap layer. Due to the limited amount (2.5 cm) of excavation and added depth of sand (10 cm), Sand-Capped Lawn plots were transitioned from 10 cm to a 2.5 cm capping depth across the final 1 m down-slope edge to tie into the surface of the concrete retaining wall containing the drain to collect runoff.

To maintain continuity with non-renovated St. Augustine grass plots, care was taken to ensure that all renovated landscapes were constructed to preserve their original 3.7% slope. An 8.2 m long × 30 cm wide × 2.5 cm deep native soil berm was also created between each plot in order to prevent lateral surface runoff flows between adjacent plots. An 8.2 m long × 10 cm deep strip of plastic edging (Terrace Board, Master Mark Paynesville, MN) was also installed down the center of the berms in order to further prevent lateral surface flow of water as well as contamination of plant or construction materials between plots. Beneath these berms, an 8.2 m long × 45 cm deep × 0.25 mm thick polyethylene liner was also installed in order to prevent lateral subsurface flow between adjacent plots.

2.3. Irrigation of landscape treatments

Artificial Turf treatments received no supplemental irrigation during the study period. The Xeriscaping and mulch landscape treatments were drip-irrigated to supply plants 1.6 L of water per week (0.8 L twice weekly) from May through October, according to a recommended rate of 0.23 L per day (Smith, 2003). During the initial two weeks of establishment, the Sand-Capped Lawn treatment was irrigated twice daily at 3 mm per event. This was reduced to one daily irrigation at 6 mm during weeks 3 and 4 of establishment. After this, both the St. Augustine grass Lawn and Sand-Capped Lawn treatments were overhead irrigated twice weekly at the warm-season turf coefficient of 60% of historical (30-year) reference evapotranspiration (60% × ETo) for the City of College Station, based on data from the Texas ET network (Texaset.tamu.edu). These bi-weekly irrigation events were further split into two start times scheduled two hours apart to minimize runoff. Adjustments to irrigation run times were not accounted for when scheduling irrigation, with the experiment mimicking a "set-it and-forget-it" practice common among urban lawn landscapes in the region. Irrigation applications rarely generated any detectable runoff from plots.

2.4. Fertilization

Artificial Turf Treatments were not fertilized during the study period. St. Augustine grass Lawn and Sand-Capped plots were fertilized at a rate of 4.9 g m^{-2} of N on 27 August 2018 using a 21–7–14 N–P_2O_5–K_2O granular fertilizer (American Plant Food Corp., Millican, TX). On 23 April, 10 July, 27 August 2019 and on 23 April 2020, St. Augustine grass Lawn and Sand-Capped plots were fertilized at a rate of 4.9 g m^{-2} of N using a 32-0-10 N-P_2O_5-K_2O granular fertilizer (Scotts Southern Turf Builder, Scotts Miracle-Gro, Marysville, OH). For Water-Efficient Xeriscaping and Mulch plots, 24-8-16 N-P_2O_5-K_2O liquid fertilizer (Miracle-Gro All Purpose Plant Food, Scotts-Miracle-Gro, Marysville, OH) was applied to planted bed areas on 29 October 2018 and on 23 April 2020.

2.5. Rainfall

Rainfall intensity (mm 2 min^{-1}) occurring during a runoff event was measured and recorded using an onsite tipping-bucket rain gauge (Isco 647, Teledyne Isco, Lincoln, NE) at a two-minute temporal resolution. Total rainfall depth (mm) during a runoff event obtained from rain gauge data were corroborated with precipitation data from an on-site weather station located near the west end of the runoff facility registered with Texas ET Network (texaset.tamu.edu), under station name of TAMU Turf Lab.

2.6. Runoff dynamics- flow and volumes

Runoff dynamics were evaluated for all naturally occurring rainfall events during the study. Flow rates (L s^{-1}) as well as total runoff volumes (L m^{-2}) from each landscape treatment were measured to determine the influence of landscape type on runoff characteristics. Flow rates (L s^{-1}) for each plot were recorded on two-minute intervals (120 s) using ISCO 4230 bubbler flow meters (Teledyne Isco, Lincoln, NE). The flow meter uses the bubbler method of level measurement, and has built-in standard level-to-flow conversions, which automatically converts the level reading (depth) into a properly scaled flow rate (the setting selected for this study was L s^{-1}) according to the primary measuring device. The primary measuring device used for this study was a 23 cm H-type flume. The measurement range of flow meter was 3 mm to 3.1 m, with the maximum level of 23 cm set for this study. More detail regarding the level-to-flow conversions for the instrumentation used can be found in Walkowiak, 2006. Total runoff volumes (L m^{-2}) were then determined by duration of the event (equation: Volume (L m^{-2}) = ($\sum$ (Flow rate (L s^{-2}) × 120 (s))) ÷ plot size (m^2)). Total runoff volume data were analyzed for all rain events.

To better characterize the response of each landscape to precipitation, hydrographs were created by plotting runoff flow rate against precipitation rate during two representative runoff events occurring on 10 October 2018 and 6 June 2019.

2.7. Data analyses

For the effect of landscape on runoff volume analysis, all data were analyzed as a single continuous experiment over two years (September 2018 to August 2020) using a three-factor (Date, Block, and Landscape) mixed-effects model for a repeated measures analysis of variance (ANOVA) (SAS 9.4, SAS Institute, Cary, North Carolina). The equation of the model is:

$$\gamma = \mu + Landscape\ (L) + Date\ (D) + Block\ (B) + L * D + Error(\epsilon)$$

Where γ is the response variable (runoff volume), μ is the overall mean, Landscape and Date are fixed factors, Block is random factor, and ϵ is the error term.

Where significant main effects (Date and Landscape) or interactions were detected, treatment means were compared using Fisher's LSD at $P = 0.05$. Where Date × Landscape interaction was significant, runoff volumes have been presented separately by landscape for each date. There is no intrinsic interest in the block, thus block won't be discussed in this paper.

Peak flow rates (L s^{-1}) of landscapes were compared at three rainfall levels, including 0 to 25 mm (Low to Moderate), 25 to 50 mm (High), and > 50 mm (Very High). These levels were modified from the classification by Li et al., 2015. Data from all runoff events for all replicated plots were included in this analysis, with using a three factor mixed-effects ANOVA to determine the effect of landscape and rainfall level on peak flow rate. The equation of the model is:

$$\gamma = \mu + Landscape\ (L) + Rain\ Level\ (RL) + Block\ (B) + L * RL + Error(\epsilon)$$

where γ is the response variable (peak flow rate), μ is the overall mean, Rain Level and Landscape are fixed factors, Block is a random factor, and ϵ is the error term. Fisher's LSD at P = 0.05 were used for Post hoc analysis.

To predict each landscape's capacity for absorbing rainfall prior to generating surface runoff, the relationships between rainfall amount (mm) and runoff volume (L m^{-2}) were investigated. Several regression models were executed using SAS 9.4 (SAS Institute, Cary, NC), including both nonlinear (using Proc NLIN) and linear models (Proc REG). Quadratic regression was determined to provide the best fit of data based on R^2 and $P \le 0.05$. Data for all rainfall and runoff events were included in this analysis with the exception of the initial runoff event, which was highly variable and not consistent with subsequent runoff data, likely due to plot settling following construction. The minimal amount of rainfall required for each system to generate runoff was then calculated according to the regression equation while setting runoff volume to zero.

3. Results

3.1. Runoff events and rainfall

During the two-year study period (September 2018 – August 2020), there were 34 runoff events from naturally occurring rainfall. Repeated measures analysis of variance showed a significant ($P < 0.05$) landscape × date interaction for runoff volumes (ANOVA results not shown). Therefore, the effect of landscape on runoff volume was evaluated separately for each date. In general, the magnitude of runoff volume closely related to the rainfall depth, and runoff was usually detected only for rainfall events exceeding ~10 mm (Fig. 3).

During the initial months of establishment (13 Sept. 2018 to 3 Jan. 2019), the effect of landscape type on runoff volume was significant for most events, but there was not a consistent trend with regard to treatment differences (Fig. 3). Also, several high runoff volume events were detected during this period (13 Sept., 17 Oct. 8, and 28 Dec. 2018, and 3 Jan. 2019) due to heavy rainfall. A 226 mm (226 L m^{-2}) rainfall event was detected on 17 Oct. 2018, which generated more than 160 L m^{-2} of runoff water from Artificial Turf, Xeriscaping, Mulch, and St. Augustine grass Lawn, and generated 133 L m^{-2} from Sand-Capped Lawn treatments.

Beginning 23 Jan. 2019, the effects of landscape on runoff volumes became more pronounced, with Artificial Turf and Xeriscaping treatments generating significantly greater runoff volumes compared to other landscapes during most runoff events. In comparison, Mulch and Sand-Capped Lawn treatments yielded the least runoff, around 50% less than that of Artificial Turf and Xeriscaping treatments for most events. The effects of St. Augustine grass lawn on runoff volumes were more complicated than other landscapes. As such, St. Augustine grass Lawn showed similar runoff volumes compared to Artificial Turf and Xeriscaping on several dates including 25 April 2019, 6 June 2019, 31 May 2019 and 28 July 2020. On other dates during the growing season

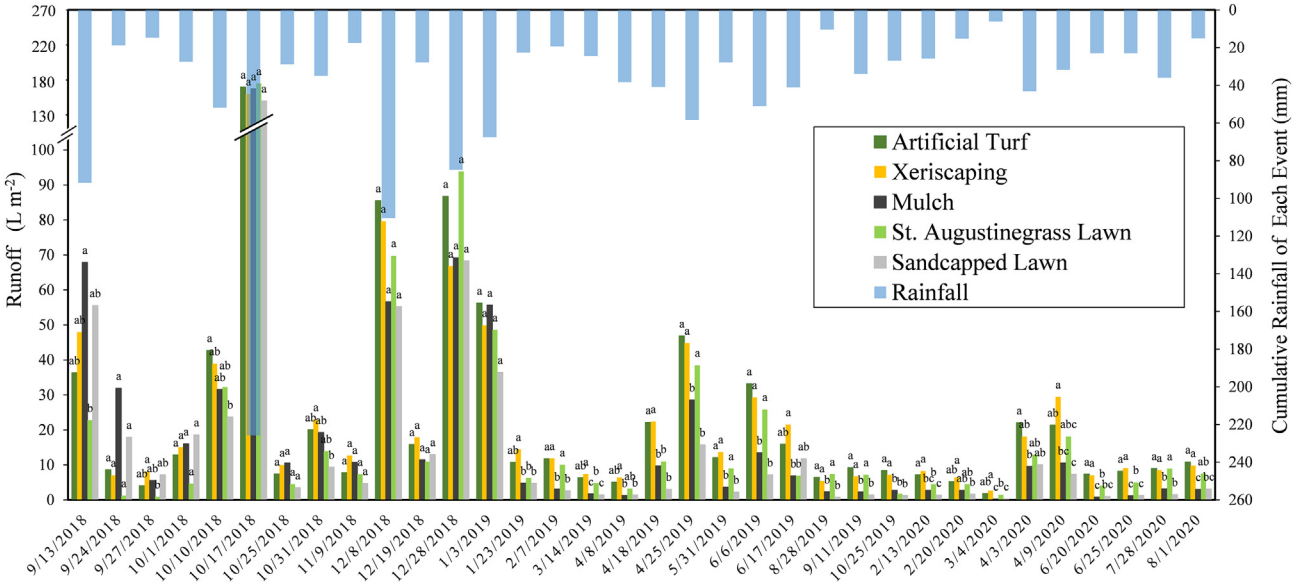

Fig. 3. Cumulative rainfall (mm) of each runoff event and total runoff (L s^{-1}) of all landscapes for each runoff event during the study period. Different lower-case letters signify a significant difference within each runoff event based on Fisher's LSD. A broken y axis was used to fit the 10/17/2018 event in the figure.

(April to October), St. Augustine grass Lawn showed much lower runoff relative to Artificial Turf and Xeriscaping, as observed on 18 April 2019, 17 June 2019, and 25 Oct. 2019.

In terms of cumulative runoff volumes for each landscape across the study period (Fig. 4), Artificial Turf and Xeriscaping showed the greatest cumulative runoff volume (>400 L m^{-2}), whereas Mulch, Sand-capped Lawn and St. Augustine grass Lawn had a significantly lower level of cumulative runoff volume, ranging from 180 to 290 L m^{-2}.

3.2. Runoff dynamics

To characterize the influence of landscape treatments on temporal runoff dynamics, hydrographs integrating rainfall intensity and flow rate over time are presented for two representative runoff events (10 Oct. 2018 and 6 June 2019) (Figs. 5 and 6). On 10 Oct. 2018, a 52 mm rainfall event occurred (Fig. 5). From this event, flow rate (y-axis) is plotted along with precipitation (z-axis), with runoff event timing (x-axis) divided into two phases, 'active rainfall' (1 pm to 5 pm) and 'sporadic rainfall' (5 pm to 9 am). For the decomposed granite-based Artificial Turf and Xeriscaping treatments, runoff flow rate mirrored the temporal pattern of precipitation during rainfall, with peak flow rate coinciding with peak precipitation. In comparison, Mulch, Sand-Capped Lawn, and St. Augustine grass Lawn treatments exhibited improved rainfall capture early on, and did not release appreciable runoff until later in the rainfall event (Fig. 5). Among all landscapes, Xeriscaping, Artificial Turf and St. Augustine grass Lawn treatments exhibited somewhat larger peak runoff flows (1 to 1.6 L s^{-1}) compared to Sand-Capped Lawn and Mulch (0.4 and 0.3 L s^{-1}, respectively). During the 12 to 15 h following the rainfall event, the runoff flows from Artificial Turf, Mulch, Xeriscaping, and Sand-Capped Lawn treatments were 5 to 10 times higher than for St. Augustine grass (Fig. 5). As such, the runoff flow rates during the hours post rainfall were 0.001 to 0.002, 0.003 to 0.005, 0.007 to 0.01, 0.01 to 0.017, and 0.015 to 0.025 L s^{-1} for St. Augustine grass Lawn, Xeriscaping, Artificial Turf, Sand-Capped Lawn, and Mulch, respectively. Thus, it can be seen that over the 12–15 h after rainfall, runoff continued to occur from all newly constructed landscapes, which contributed in part to their overall runoff volumes.

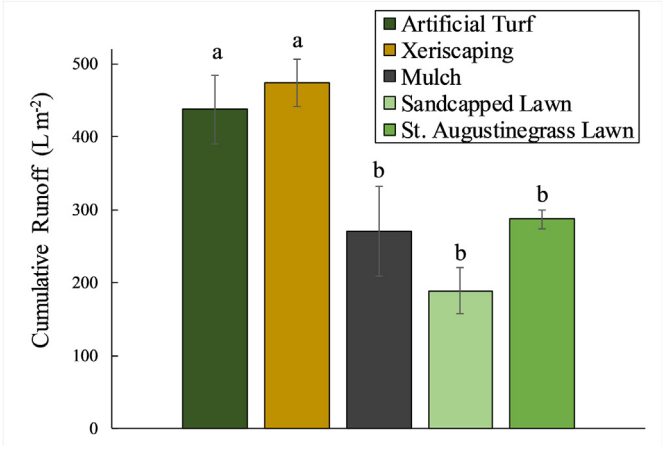

Fig. 4. Cumulative runoff derived from rainfall for landscapes including Artificial Turf, Xeriscaping, Mulch, Sandcapped Lawn, and St. Augustine grass Lawn, during the study period (September 2018 to August 2020). Different lower-case letters signify a significant difference based on Fisher's LSD. Bars represent standard error.

Runoff dynamics for the landscape treatments for the 6 June 2019 rainfall event was for a similar precipitation event (51 mm), but after the plots had been established for almost one-year (Fig. 6). These data indicate a change in the hydrological response of landscapes to rainfall when comparing to 10 Oct. 2018 event, as there was no "long-tail" after rainfall runoff for the 6 June 2019 event. All treatments generated runoff during this precipitation event, with the highest flow rates detected for Artificial Turf (peak of 0.25 L s^{-1}) and Xeriscaping (peak of 0.27 L s^{-1}), followed by St. Augustine grass Lawn (peak of 0.19 L s^{-1}). The lowest peak flow rate was associated with Sand-Capped Lawn (0.10 L s^{-1}) and Mulch (0.12 L s^{-1}). Where other treatments showed moderate increases in runoff flow occurring around 7:00 a.m., only minor increases in flow were seen at this time for these two landscapes (Fig. 6).

3.3. Peak flow

The peak flow of all landscapes increased with increasing rainfall level (mm), and a significant interaction between rainfall level and landscape was detected for peak flow rates (Fig. 7). As such, when rainfall was less than 50 mm, the highest peak flow rates were detected for xeriscaping, which showed peak flows of 0.3 L s^{-1} for low to moderate rainfall (0–25 mm) events and peak flows of 0.4 L s^{-1} for high rainfall

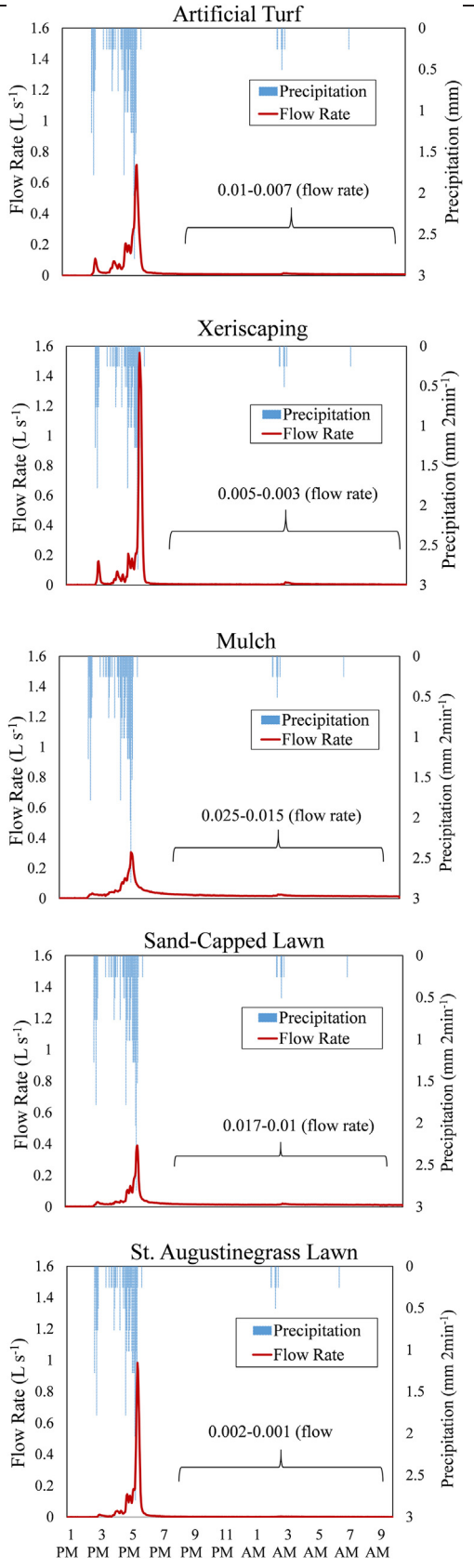

Fig. 5. Runoff flow rates (L s^{-1}) occurring from each landscape during 10 Oct., 2018 rain event. Active rainfall was during the daytime of 1 pm to 6 pm, with scattered rainfall lasted till 7 am of next day. Flow rate and precipitation were measured on 2-min intervals. Red solid line indicates flow rate and blue bar indicates precipitation rate (mm 2 min^{-1}). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

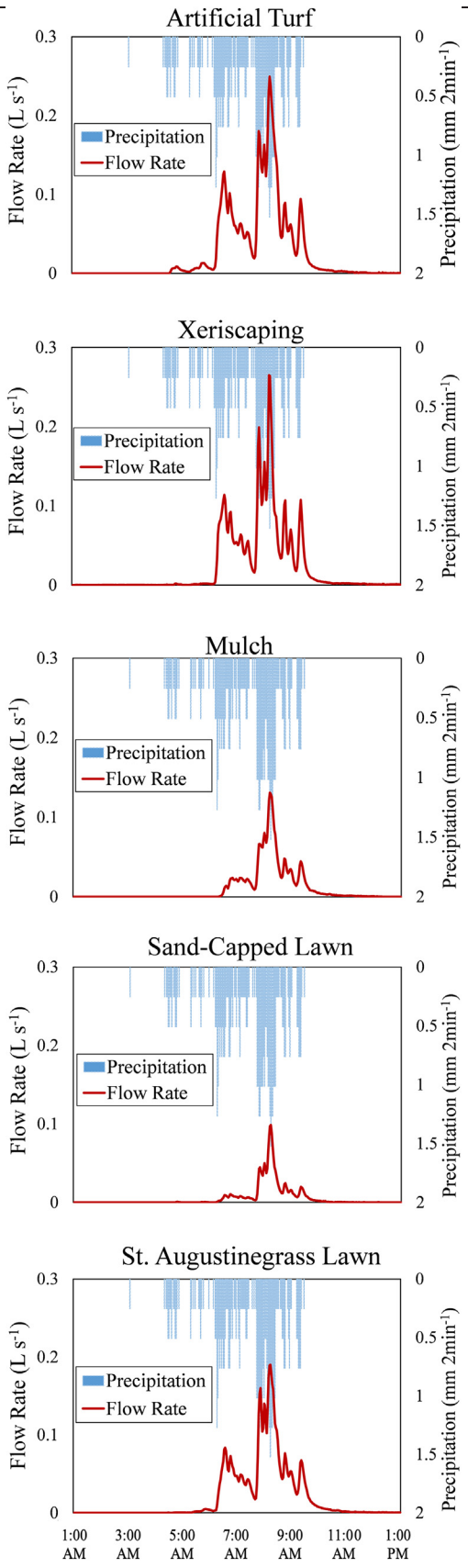

Fig. 6. Runoff flow rates (L s^{-1}) occurring from each landscape during 6 June 2019 rain event. Flow rate and precipitation were measured on 2-min intervals. Actively rainfall was during the daytime of 3 am to 11 am. Red solid line indicates flow rate and blue bar indicates precipitation rate (mm 2 min^{-1}). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

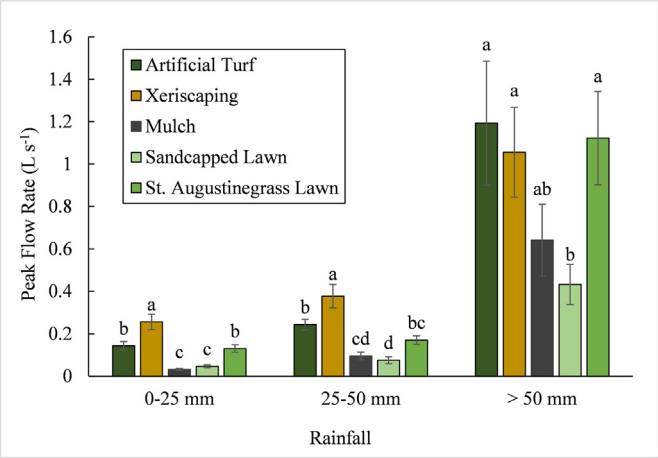

Fig. 7. Peak flow rate ($L\ s^{-1}$) of 5 urban residential landscapes under 3 rainfall levels. 0–25 mm, 25–50 mm, and >50 mm, represents rain level of low to moderate, high, and very high, respectively. Data were pooled across all events that falls into each category. Different lower-case letters signify a significant difference based on Fisher's LSD at each rainfall level. Bars represent standard error.

(25–50 mm) events. Artificial turf and St. Augustine grass lawn maintained intermediate peak flow rates, ranging from 0.1 to 0.2 L s^{-1}. The lowest peak flow rates were observed for mulch and sand-capped lawn plots, which were less than 0.1 L s^{-1} under rainfall levels of 0–50 mm. The only significant differences between treatments with regard to peak flow rates were found when comparing Sand-capped Lawn (0.4 L s^{-1}) to Artificial Turf (1.2 L s^{-1}), St. Augustine grass Lawn (1.1 L s^{-1}), and Xeriscaping (1.1 L s^{-1}) treatments at rainfall levels exceeding 50 mm.

3.4. Rainfall capture by landscapes

Quadratic regression of runoff volumes and total rainfall was performed to determine the minimal amount of rainfall required to generate runoff from each landscape (Fig. 8). The calculated R^2 for the regression for Artificial Turf, Xeriscaping, Mulch, St. Augustine grass treatments were all somewhat higher ($R^2 > 0.86$) than Sand-Capped Lawn ($R^2 = 0.77$). Diagnostic analyses including residuals plots and Q-Q plot, etc. (data not shown) indicated that the model assumptions were met for Artificial Turf, Xeriscaping, Mulch, St. Augustine grass. While violation of heteroskedasticity was detected for Sand-Capped Lawn, the actual gradient of the tread line was still unbiased, and thus the same model was used for Sand-capped Lawn. The greater variability in Sand-Capped Lawn treatment was likely the result of greater runoff volumes as a fraction of rainfall during the initial fall season, when plots were irrigated frequently and belowground organic matter had not yet accumulated in plots. Results of quadratic regression analysis indicated Sand-Capped Lawn showed the highest capacity for rainfall capture, with runoff not occurring until rainfall exceeded 22.2 mm (Fig. 8). This was followed by Mulch (18.5 mm rainfall required), St. Augustine grass Lawn (15.7 mm rainfall required), Artificial Turf (13.5 mm rainfall required), and Xeriscaping (10.2 mm rainfall required).

4. Discussion

Competition for potable water supplies has increased dramatically as society has become more urbanized in recent decades. In addition to improved irrigation technologies and day-of-the week irrigation restrictions, landscape conversion rebate programs have been one way a growing number of municipalities have attempted to achieve reductions in outdoor water usage (Austin Water, n.d. website; Valley Water, 2020 website; Chesnutt, 2019; Pincetl et al., 2019). Altered patterns of stormflow concomitant with urbanization and its associated land disturbance increase humankind's vulnerability to natural hazards such as floods and hurricanes (Hur et al., 2008; DeBusk and Wynn, 2011; Burns et al., 2012; Walsh et al., 2012). Water losses derived from surface runoff from landscapes are often accompanied by fertilizers, insecticides, herbicides, and pet waste (Revitt et al., 2002; Smith et al., 2007; Jiang et al., 2012; Yang and Lusk, 2018). Previous studies investigating the impact of landscape disturbance on the surface runoff have been conducted on a broader scale, with few directly comparing runoff dynamics among specific landscape types (Holman-Dodds et al., 2003; Olivera and DeFee, 2007; Woltemade, 2010; Sjöman and Gill, 2014). Specific, in depth information is needed to guide municipalities, policy makers, and landscape architects to make better decisions regarding landscape conversions and their impacts on entire urban ecosystem.

4.1. Runoff events and dynamics

In this study, runoff dynamics differed both between landscapes, but also changed over time as the landscape conversion became established, which may have been due to alteration of physical properties of newly constructed landscape materials (mulch and decomposed granite) over time through due to settling, compaction, and soil aggregation. This is partially supported by the observation that during the initial months of the study, a considerable amount of suspended solids was measured in runoff from Xeriscaping, and to some extent, Mulch treatments (Chang, 2020). Loss of this relatively fine fraction over time may also have altered rainfall capture and water-holding and release dynamics. For example, the newly applied mulch showed the highest runoff volumes during the first two rainfall events, but thereafter showed the least runoff of all treatments. It appears that this may have been due in part to the influence of physical properties of the mulch on water-holding capacity and release after rain events. Early on, during the fifth rainfall event of the study, mulch appeared to release water over a considerably longer period time after rainfall compared to other landscapes, with the post-rainfall flow rate nearly 10 times higher than other landscape treatments (Fig. 5), and this likely contributed to the higher total volume of runoff from mulch during the early stage of the study (Fig. 3). Later on in the study, however, this extended runoff duration was not seen for the Mulch treatment. We suspect that greater settling and aggregation of mulch over time may have contributed to enhanced water holding capacity, which in turn, reduced duration and extent of runoff losses.

Relatively higher runoff volumes were also observed for Sand-Capped Lawn in the early months of this study (Fig. 3). We speculate this was primarily due to the frequent irrigation inputs that were required to establish the washed sod on the sand root zone during the initial month, and resultant impacts on higher soil moisture content. Furthermore, sand-capped lawn treatments would have gradually accumulated greater amounts of organic matter in the upper sand-cap layer over the first full season, which would likely have improved water holding capacity and contributed to runoff reductions over time.

Beginning spring 2019, after plots were established and settled in, and through the end of the study, Sand-Capped Lawn and Mulch generally had significantly lower runoff volumes than all other landscapes. The native soil-based St. Augustine grass Lawn maintained moderately low runoff volumes, while Xeriscaping and Artificial Turf each showed the highest runoff volumes (Fig. 3). It should be noted that, in addition to factors such as particle size density and infiltration rates of the basing material (decomposed granite, mulch, sand, or soil) used, antecedent soil moisture is another important consideration affecting runoff amounts. For example, on 28 July 2020, St. Augustine grass had just been irrigated prior to a 36 mm rainfall, which led to similarly high runoff volumes between St. Augustine grass, Artificial Turf, and Xeriscaping (the latter two of which received drip or no irrigation). Overall, rainfall immediately followed irrigation only three times during the study period. In addition, actively growing warm-season turfgrasses can

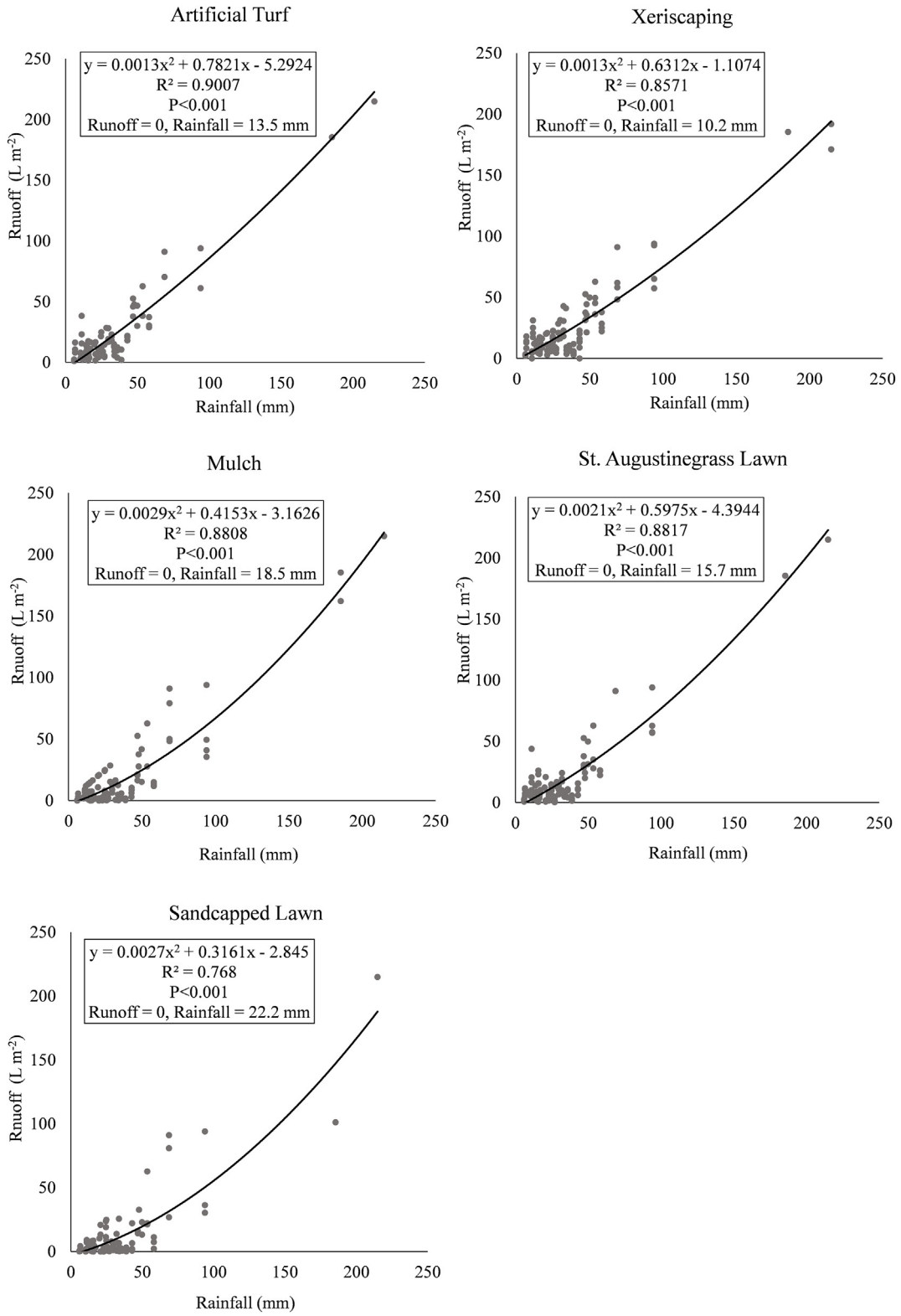

Fig. 8. Quadratic regression of rainfall (mm) and runoff (L m^{-2}) for each landscape during the study period (September 2018 to August 2020). The least amount of rainfall that is required for each system to generate runoff was calculated according to the regression equation with setting runoff volume to 0.

consume more than 3 cm of water weekly during the growing season which can results in significant changes in soil moisture content from day to day during the growing season (Kim and Beard, 1988). Soil moisture depletion due to grass evapotranspiration during the active growing period (summer-fall) likely contributed to observed runoff differences when comparing St. Augustine grass lawn to Xeriscaping and Artificial Turf plots. Similarly, Fontanier et al. (2017) previously demonstrated that deficit irrigation of St. Augustine grass lawn turf reduced summer and early autumn runoff volumes, which highlights the important of antecedent moisture conditions on runoff generation.

The landscape base materials used in this study (decomposed granite, mulch, coarse sand, and native soil) clearly played a role in water

infiltration and capture as well as runoff dynamics, however, infiltration rates were not directly measured in this study. While we are not aware of any studies of this exact nature, related studies have been conducted comparing runoff among different urban surfaces including fully pervious, relatively pervious, and impervious soil surfaces (Boyd et al., 1993; Holman-Dodds et al., 2003; Shafique et al., 2018). Runoff as a fraction of precipitation is lower on high-infiltration capacity soils and higher on low-infiltration capacity soils (Holman-Dodds et al., 2003). However very few studies have been conducted to directly compared the infiltration rates of different landscape types, and conflicting results exist in terms of determination of the effects of turfgrass on soil infiltration rate. Turfgrasses have been shown to have a positive impact on reducing runoff compared to other surfaces, and this primarily results from the high shoot density and presence of thatch in turfgrasses (Beard and Green, 1994; Easton and Petrovic, 2004; Liang et al., 2017). Woltemade (2010) determined the impacts of residential soil disturbance on soil infiltration rates and storm water runoff and found that soil infiltration rates differed considerably between residential lawns and agricultural areas, with lawns having measured saturated infiltration rates of 2.8 cm per hour compared to 10.2 cm per hour for agricultural areas.

4.2. Peak flow and rainfall intensity

Another interesting observation was that effect of landscape type on runoff mitigation was insignificant when rainfall exceeded 60 mm, and this was the case for four events during the study (17 Oct. 2018, 8 Dec. 2018, 28 Dec. 2018, and 3 Jan. 2019 (Fig. 3). This finding appeared to be largely driven by the high rainfall intensity during these events, rather than overall amount alone. This can be seen in the peak flow results (Fig. 7). As such, when rainfall amount exceeded 50 mm, differences in the peak flows between landscapes were less apparent. These observations suggest that the effects of landscape composition on runoff volumes are less significant with greater rainfall intensities. Similarly, a previous study that investigated the effect of rainfall intensity, grass type, and vegetation coverage on stormwater runoff of urban green spaces confirmed that rainfall intensity had the highest influence among all factors on surface runoff (Yang et al., 2013).

4.3. Rainfall capture by landscapes

Relative runoff or runoff coefficients, calculated as a percentage of rainfall and lag time between the center of precipitation volume and center of runoff volume have been widely used to characterize the ability of a landscapes to capture rainfall (Paul and Meyer, 2001; Moreno-de Las Heras et al., 2009; Loperfido et al., 2014; Zhang et al., 2015; Liu et al., 2018). For example, Zhang et al. (2015) generated runoff coefficients for various land cover types, and determined the coefficient for residential grass to be 0.23 to 0.34 (i.e. 23–34% of incoming precipitation is runoff). Liu et al. (2018) showed relative runoff of 0.25 to 0.75 for landscapes with vegetation cover of 50%, and noted this number could be decreased to 0 to 0.5 when vegetation cover approached 100%. In this study, a different approach was used to characterize the ability of a landscapes to capture rainfall. Based on the results, rainfall capture by Sand-Capped Lawn and Mulch landscapes was nearly double that of Xeriscaping and Artificial Turf. However, there was a limitation of the current model due to the lack of data on antecedent soil moisture, which has been well documented to influence runoff volumes (Wei et al., 2007; Zhang et al., 2011; Schoener and Stone, 2019). Thus, future studies should also consider soil moisture data for more fully characterizing the complexity of factors influencing runoff.

4.4. Implications

To our knowledge, this is one of the first studies aimed at investigating hydrological impacts of urban residential landscapes on a small scale using a replicated treatment design. One challenge with this type of research is there is no universal landscape type for all urban areas. Our treatments were designed based on our site's climate, locally adapted plants, commonly used basing materials, and recommendations from a local professional architect. Based on the results of this study, it appears that while requiring more water, lawns also offer enhanced rainfall capture/runoff control compared to xeriscaping and artificial turf systems. Although sand-capping is a relatively recent practice in construction and renovation of golf course and sports fields (Dyer et al., 2020), it has not been widely adopted in urban landscapes. Our research suggests that sand-capping may offer improved rainfall capture and runoff mitigation compared to traditional lawn established atop native, clay or loam soils. Also, it may be challenging to extrapolate our findings to landscape situations in other climates, as differences in rainfall, soils, and temperature may have produced somewhat different results. Also, the desired ecosystem services provided by a given landscape may differ based on societal preferences, desired function, and available resources for maintaining such landscapes.

5. Conclusion

The results of our study demonstrate the importance of landscape composition on runoff dynamics and volumes. Generally, landscapes with greater compaction and/or based with materials containing finer particles, such as xeriscaping and artificial turf, would have higher potential of runoff generation. In this study, traditional lawns and sand-capped lawns showed superior runoff control, especially during the growing season. In the future, similar studies should be conducted under different climates in order to provide region-specific recommendations. The environmental impacts of landscape conversions are not limited to runoff, so future studies should also consider dynamics including energy balance, water quality, and air pollution. In addition, the total impact of landscape construction and associated materials on the environment should be considered. Collectively, the information gained from this research could benefit municipalities, water purveyors, and homeowner associations as they weigh the long-term benefits and consequences of lawn removal and landscape conversion programs.

CRediT authorship contribution statement

Baoxin Chang: Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization, Funding acquisition. **Benjamin Wherley:** Conceptualization, Methodology, Resources, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Jacqueline A. Aitkenhead-Peterson:** Methodology, Resources, Writing – review & editing, Funding acquisition, Supervision. **Kevin J. McInnes:** Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that there is no conflict of interest.

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Research Paper

Intense summer heat fluxes in artificial turf harm people and environment

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HIGHLIGHTS

- High air-cum-surface temperature of artificial turf raises concerns on player health.
- Solar & terrestrial radiation and temperature at five levels were monitored in summer.
- Artificial turf admits more solar and emits more thermal radiation than natural one.
- Artificial turf with low specific heat and moisture incurs fast heating and cooling.
- Cooler periods fit for matches were identified on sunny, cloudy and overcast days.

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ABSTRACT

Artificial turf (AT) sports fields have increasingly replaced natural turf (NT). High AT material-cum-air temperature incurs heat-stress impacts on athletes, demanding better understanding of thermal regimes vis-à-vis weather conditions. Adjacent AT and NT sites in humid-tropical Hong Kong were studied. Four radiant-energy components (direct-solar, reflected-solar, sky-thermal, ground-thermal) and five temperature levels (150, 50 and 15 cm, turf-surface, substrate) were monitored in replicate, for three summer weather conditions (sunny, cloudy, overcast). Inter-site differences are attributed to lower AT albedo, admitting more shortwave and emitting more longwave radiant energy. Drastic decline in solar fluxes contrasts with terrestrial fluxes which remain intense. AT materials, with low specific heat and moisture and scanty evapotranspiration, induce fast warming and cooling with little time lag to synchronize with insolation rhythm. On sunny day, AT turf-surface, heated to 72.4 °C comparing with NT at 36.6 °C, dissipates heat by conduction and convection to near-ground air and by strong ground-thermal emission. Exceeding the heat-stress threshold most of the time, AT cools quickly from late afternoon for heat-safe use soon after sunset. On cloudy day, subdued AT heating allows earlier cooling in late afternoon. Both sites are heat-safe on overcast day. The findings can optimize game scheduling to prevent heat-related injuries.

1. Introduction

Some natural turfgrass sports fields are beset by problems in material, design, maintenance and use impact. They could suffer from chronic turf deterioration and hence degradation in site quality, with implications on player satisfaction and performance. Different management responses have been adopted to tackle the problems. The proactive measures include improving turf constitution, care, growth and durability. In contrast, the passive approach calls for notable reduction in turf wear by trimming the duration and the intensive types of use. The more drastic reaction would replace natural turf (NT) with artificial turf (AT), which has been advocated as a less costly, easier to maintain and more durable alternative.

The first-generation AT invented in the 1960s was akin to a green-colored carpet (Fleming, 2011; McNitt, 2005). Gradual evolution in material and technology has moved towards emulating the real grass in terms of appearance, feel, and playability. The present third-generation AT, emerging in the 1990s, has longer and upright fibers (or piles) which mimic linear grass leaf blades. The granular infill materials that bury the lower part of the piles mimic the mineral soil substrate of NT. The common infill substances are rubber granules or silica sand, or a mixture of both. The shockpad laid immediately below the backing sheet of the piles enhances resilience of the playing surface. Most AT fields use recycled rubber

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tire shredded into small fragments for the infill and the shockpad. Usually the synthetic Styrene Butadiene Rubber (SBR) is employed, purportedly advocated as a contribution to environmental protection by giving a second lease of life or adaptive use to an otherwise waste material facing thorny disposal problems (Madison Athletic Foundation, 2011).

Five decades of AT use and studies have accumulated a rich body of knowledge on its characteristics, management and player response. The main concerns include the interface between player and surface, and between ball and surface, which were compared with NT serving as the default standard. Deviations from NT could undermine player satisfaction and performance, and may induce more frequent and serious injuries. A more critical issue is the inordinately hot AT surface which could exceed NT by 30 °C–65 °C on hot summer sunny days (Buskirk, Mclaughlin, & Loomis, 1971). The undesirable heat impacts on the comfort and health of players, especially at a surface temperature above the 45 °C heat-pain threshold, were evaluated by Kandelin, Krahenbuhl, & Schacht (1976). Subsequent studies in various cities in the temperate climatic zone and using different AT types have found similarly elevated surface temperature (Brakeman, 2004; Fresenburg, 2005; McNitt and Petrunak, 2007; Petrass, Twomey, & Harvey, 2014; Petrass, Twomey, Harvey, Otago, & LeRossignol, 2015; Sciacca, 2008; Williams and Pulley, 2002).

The relationship between some meteorological parameters and AT surface temperature was verified by Ramsey (1982), and Petrass et al. (2014) who also found an association with AT materials. The heat energy, derived from solar radiation and stored in the AT materials, could in turn warm the near-surface air mainly by conduction and convection (Aoki, Matsuda, Toyoda, 2005; Aoki, 2011; Brakeman, 2004; Kandelin et al., 1976; McNitt, 2005; Ramsey, 1982). The hot radiating surface and warmed air could raise the body temperature of players to a harmful level. In acute situations, they could suffer from heat stroke and even mortality (Aoki et al., 2005; Howe and Boden, 2007).

The ball games played under high temperature conditions could lead to heat stress and heat injury, with implications on athlete performance, health and professional lifespan (Claudio, 2008; Department of Sport & Recreation, 2011). To avoid mishaps, game scheduling has been adopted by the management to reduce the ill effects on players (Grundstein et al., 2014; Kajiwara, Ono, Nakai, Kimura, & Nozaki, 2005).

The looming climate-change impacts are accentuated in cities due to superposition of the urban heat island (UHI) effect. NT sites are important parts of the urban green infrastructure (UGI) which can provide the welcomed cool island effect. Increasing conversions of NT to AT could intensify the UHI effect and counteract the efforts to cool cities by the cost-effective and sustainable means of urban green spaces (UGS). Predicting and avoiding extremely hot periods is preferred to disruptive and unwelcomed cancellations. With climate change, more heat waves are expected in conjunction with increasing frequency and magnitude of extreme weather (Amengual et al., 2014; IPCC, 2013). The heat impacts of AT in terms of intensity and duration could be accentuated. Based on weather data and forecast in summer, days and time-periods with high risk can be avoided for practices and matches. To optimize schedule management, the magnitude of the aberrant heat regimes of artificial versus natural turf could be evaluated on selected summer days.

From a survey of the AT literature cited above, some notable knowledge gaps could be identified. As a relatively new field of study, the number of research papers is limited and the research methods are being developed progressively. Existing studies on AT microclimate concentrate on taking temperature readings in the daytime. The 24-h diurnal-cycle monitoring would have deciphered the heat exchanges in nighttime which is an integral part of the energy budget. Most studies report temperature records on the turf surface and sometimes at one height above the ground. Few would track the vertical air temperature profile at different heights as well as the turf surface and substrate. Most importantly, there is a lack of evaluation on the pertinent solar and terrestrial radiation fluxes which are the fundamental driver of the heat build-up and thermal regime of AT fields. Moreover, most studies focus on the fine-sunny weather condition, and ignore the overcast and rainy weather types. They look at one AT field without comparing it with an NT field to identify the major differences. Almost all studies were conducted in temperate climate, with few in the tropical zone. Overall, there is a lack of a detailed investigations on the holistic energetics and thermal behavior of AT, and their intimate association.

This experiment was developed to fill the above knowledge gaps, with the help of state-of-art environmental monitoring equipment especially regarding collection of accurate data on solar and terrestrial radiation. The main research questions are: (1) What are the pathways and magnitudes of heat fluxes in AT and NT under three main summer weather conditions? (2) What are the key characteristics of the thermal regime at different heights and times of the day at AT vis-a-vis NT? The study was designed to test two hypotheses: (1) The shortwave and longwave radiant-energy budget plays a key role in determining the heat fluxes of AT; and (2) The inherent physical properties of AT materials dictate its thermal regime and stress on athletes. As the study is concerned with the heat dynamics of the AT system, it concentrates squarely on the summer season. The NT field was included in the experiment as a control or a baseline to assess the thermal deviation of AT from the normal expectations of a conventional NT sports field. It is hoped that this study could generate new knowledge to improve understanding of the AT high-temperature phenomenon using a holistic radiant-energy approach.

Based on humid-tropical Hong Kong, this study assessed with the help of field experiments the heat fluxes and thermal regimes of AT vis-à-vis NT in summer. Key climatic parameters were monitored in diurnal cycles. Data of three weather types, namely sunny, cloudy and overcast days, were collected. Solar and terrestrial radiant energy components, both incoming and outgoing, were measured in conjunction with temperature at different heights, on turf surface, and in substrate. The radiant and thermal regimes of AT and NT were compared with reference to the three weather types. The thermal ambience of the two turf fields in relation to weather was ascertained.

2. Study area and methods

2.1. Experimental site

Hong Kong is situated at the northern edge of the Asian tropical zone in south China, at latitude 22°N. The regional weather is mainly regulated by the large-scale Monsoon system. It brings ample rainfall and humid condition in summer, and a cool-dry winter (Hong Kong Observatory, 2015a). The annual rainfall reaches 2400 mm, mainly dropped in the wet season extending from May to September, often associated with thunderstorms, typhoons (tropical cyclones), and heavy frontal rains. The summer temperature often exceeds 30 °C, but winter tends to be mild and seldom dropping below 10 °C. The intervening spring is warm and humid, whereas autumn is warm and dry. On sunny summer days, global solar radiation is intense, which may exceed 900 Wm^{-2} around midday to bring daily global solar radiation usually over 20 $MW\,m^{-2}$ (Chong and Lee, 2015).

The weather records are indicating climate change, including rising average temperature of 0.6 °C per decade in 1985–2014,

exceeding the long-term 1885–2014 average of 0.12 °C per decade (Hong Kong Observatory, 2015b; Lee, Chan, Ginn, & Wong, 2011). Meanwhile, extreme weather events for rainfall (hourly rainfall ≥100 mm, 2-hourly rainfall ≥150 mm, 3-hourly rainfall ≥200 mm) and extremely hot days (≥35 °C) have become more frequent as expressed by notably shortened return periods. The impacts on outdoor workers and athletes on hot summer days call for preventive actions. The community expects the administration to mitigate the effect of climate change which has been compounded by the aggravating UHI effect (Lo and Jim, 2015).

The exceptional compact urban development mode in Hong Kong is characterized by dense packing of high-rise buildings and roads. Due to the rugged topography and shortage of flat and easily developable land, the 7.24 million population is accommodated in merely 250 km^2 of built-up areas, occupying about a quarter of the 1108 km^2 land area (Planning Department, 2015). UGS are seriously lacking, with public urban open-space provision at merely 2.84 m^2/person, which is one of the lowest in the world for comparable large cities (Jim and Chan, 2016). The deprivation of UGS restricts opportunities for outdoor recreation with health and quality-of-life implications (Hong Kong Council of Social Service, 2014), and gravely limiting the contributions of greenery to cooling and UHI mitigation (Jim, 2015).

The experimental sites are situated at the sports center of the University of Hong Kong, at a coastal location with a high skyview factor, excellent exposure to sunlight, and high permeability to wind and ventilation (Fig. 1). It has four rectangular sports fields, three of which have been converted to artificial turf. The study evaluated the microclimate of AT which was compared with NT serving as the baseline. The experimental design demands adjacency of the two fields to ensure that they are exposed to similar solar radiation and general weather conditions. The fields are designed for soccer and hockey games, and they meet the guidelines stipulated by the relevant international bodies, namely the International Federation of Football Associations (FIFA, 2015) and International Hockey Federation (FIH, 2014).

The NT site is planted with a cultivar of Bermudagrass (*Cynodon dactylon*) with a fine texture and tolerance of relatively cool winter weather. It can remain green and robust through the cool-dry winter months, and grows vigorously in the hot-humid summer. The substrate is a prepared soil mix composed of local well-weathered granitic material, with the topsoil enriched with organic matter (Jim, 1996). Drainage is facilitated by surface crowning and subsoil drain pipes. An automatic sprinkler irrigation system provides supplementary watering.

A third-generation product was installed at the AT field (Fig. 2). The synthetic grass leaves are composed of 35-mm long green-colored polyethylene mono-filament fibers. The AT pile is held upright by granular infill, including an upper 8-mm layer of rubber granules made of shredded recycled rubber tires, and a lower 10-mm layer of quartz sand. The fibers are weaved into a double backing sheet made of polypropylene and polyester and fixed to it by an adhesive coating. The backing sheet is perforated to allow water to drain downwards. The above materials are underlain by a 25-mm recycled rubber-pellet shockpad to improve resilience of the playing surface. Below the shockpad, a 65-mm layer of no-fines concrete offers the firm and flat base that allows free drainage. The site soil lying below it serves as the sub-base which is equipped with corrugated plastic drain pipes.

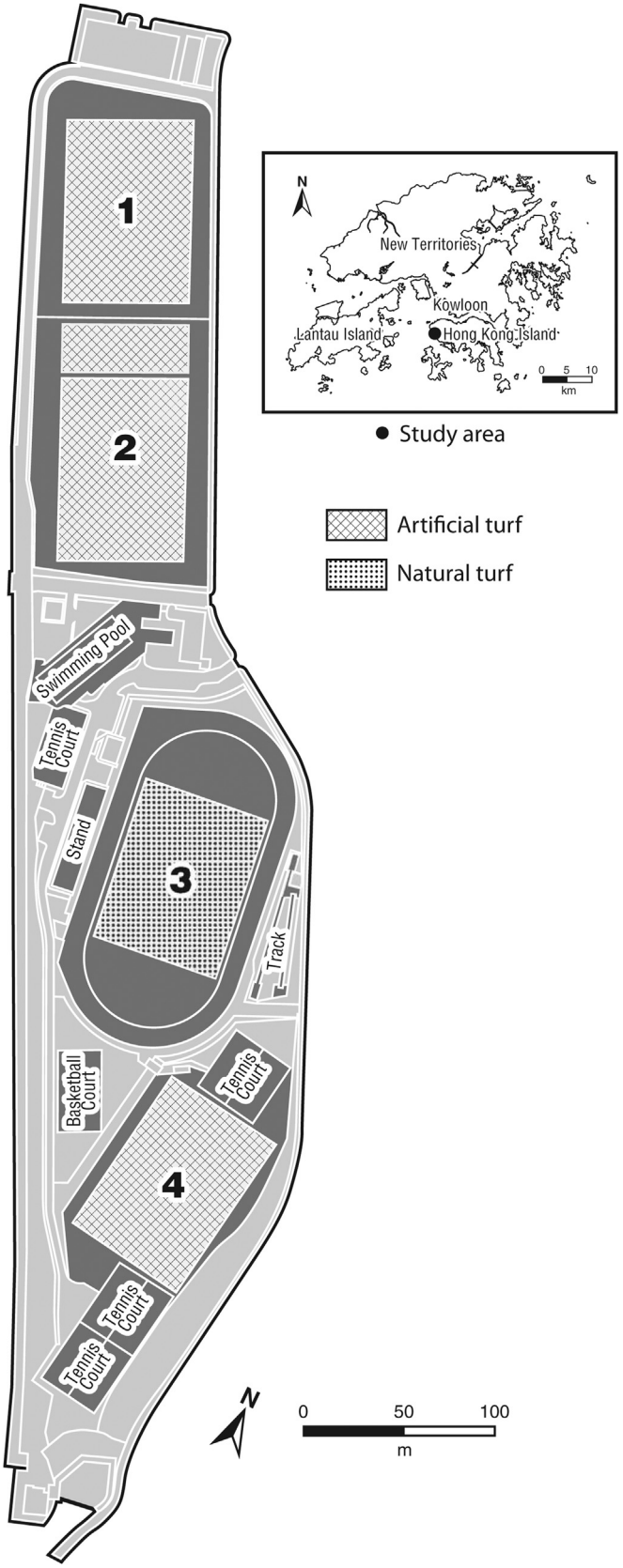

Fig. 1. Location of the study area which is the sports fields of the University of Hong Kong situated at a western coastal strip of Hong Kong Island as indicated by the inset map. Field 2 artificial turf and adjacent field 3 natural turf were chosen for the microclimatic monitoring.

2.2. Experimental design

The two turf sites were given the same experimental treatments. Each site was equipped with two similar microclimatic monitoring stations (Fig. 3). Each station contained the following research-grade environmental sensors with weather-proof design

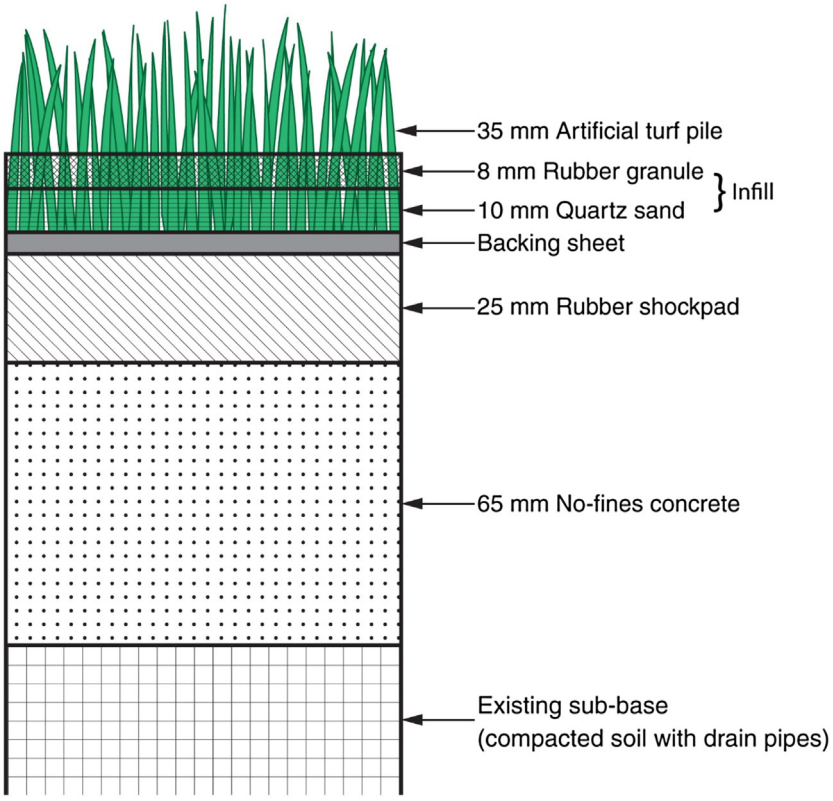

Fig. 2. Cross-sectional view of the third-generation artificial turf at the study site showing the vertical sequence of different material layers.

Table 1
Environmental monitoring sensors used in the field experiment to measure temperature, humidity, radiation, wind and rainfall at the natural and artificial turf sites.

Sensor and installation position[a]	Sensor type	Accuracy & unit	Brand, model and manufacturer location[b]
(a) Temperature:			
Air 15, 50 and 150 cm	Thermister	±0.2 °C	Hobo S-THB, Bourne, MA, USA
Turf surface	Infrared radiometer	±0.2 °C	Apogee SI-111, Logan, UT, USA
Substrate at 6 mm depth	Pt100	±0.4 °C	Lufft 8160.TF, Fellbach, Germany
(b) Relative humidity:			
Air 15, 50 and 150 cm	RH sensor	±2.5%	Hobo S-THB, Bourne, MA, USA
(c) Radiation (at 160 cm):			
Solar incoming and outgoing	Net radiometer	<5% W m^{-2}	Kipp & Zonen CNR4, Delft, Netherlands
Terrestrial incoming and outgoing	ditto	<5% W m^{-2}	ditto
(d) Weather station[c] (at 160 cm):			
Wind speed and direction	Cup anemometer	±0.5 m/s	Hobo S-WCA, Bourne, MA, USA
Rain gauge	Tipping bucket	±1.0% mm	Hobo S-RGB, Bourne, MA, USA

[a] Each turf site was equipped with two monitoring stations including the same set of sensors to acquire duplicate data.
[b] The Lufft Opus 200 and 208 data loggers (Fellbach, Germany) were synchronized and programmed to acquire data at 15-min interval.
[c] Wind and rain measurements were taken at one of the two monitoring stations at each turf site.

for outdoor use. The manufacturer and accuracy information of the sensors are summarized in Table 1:

(a) Two pyranometers, covering the shortwave spectral range of 300–2800 nm, pointing upwards and downwards to measure respectively direct and reflected solar radiation (Kipp and Zonen, 2009).
(b) Two pyrgeometer with longwave spectral range of 4500–40,000 nm, pointing upwards and downwards to measure respectively sky thermal and ground thermal radiant energy (Kipp and Zonen, 2009).
(c) The above four sensors were fitted by the manufacturer in a four-in-one net radiometer design with a built-in temperature sensor for temperature correction of the measured data. The four readings allowed establishment of the radiant energy budget for both solar and terrestrial radiation at the study sites. The overall net radiation for each site could be computed.
(d) Air temperature at 150, 50 and 15 cm from the ground using thermister probes equipped with radiation shield.
(e) Turf surface temperature using a non-contact infrared radiometer.
(f) Substrate temperature using a Pt100 soil temperature probe buried at 6 mm depth.
(g) Relative humidity at 150, 50 and 15 cm from the ground using the capacitive type of sensors.
(h) Wind speed and direction at 160 cm height using a cup anemometer and a wind vane.
(i) Rainfall at 160 cm height using a tipping-bucket rain gauge.

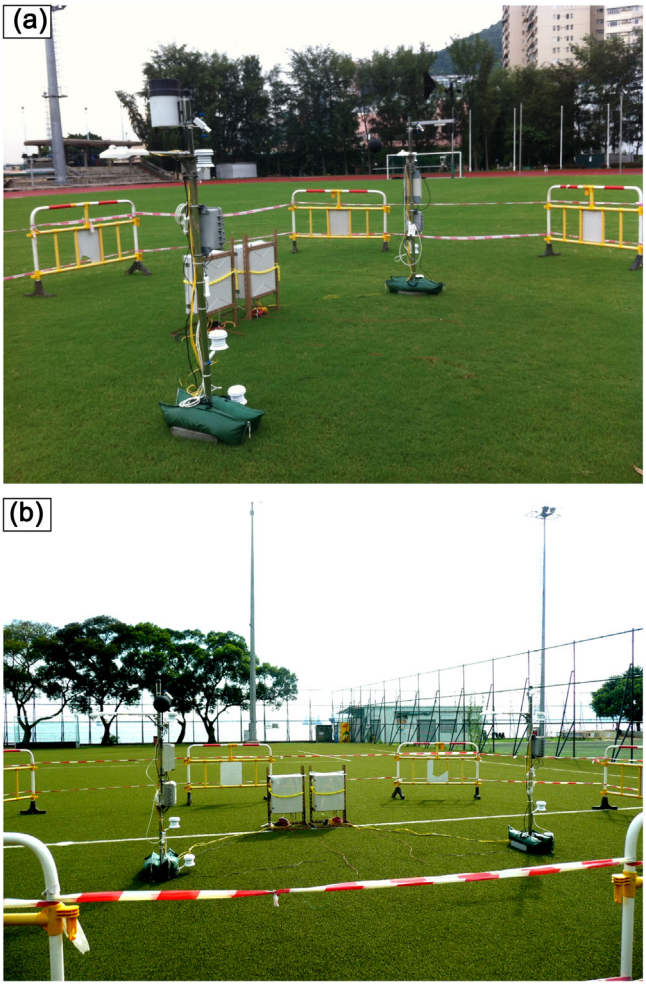

Fig. 3. The replicate microclimatic sensors and dataloggers installed at two fields at the sports center of the University of Hong Kong: (a) Natural turf (NT); and (b) Artificial turf (AT).

(j) The monitoring data were acquired at 15-min intervals and stored in data loggers for periodic transfer to a notebook computer.

The study was conducted in summer 2014. As the university sports center was heavily used throughout the year, especially in summer, the request to have continuous monitoring for two months could not be approved. Instead, the manager permitted booking only of some assigned two-day slots both turf fields in July to August, which are the hottest months. The intention was to capture three types of summer weather conditions, namely sunny, cloudy and overcast. The captured days have weather conditions that fall within the average conditions based on the 30-year weather normals of the local weather station (Hong Kong Observatory, 2016). Replication to improve data reliability was achieved in two ways. Firstly, two microclimatic stations were installed at each turf site collecting two sets of data concurrently. Secondly, more than one day of data were collected for each weather type. As the data of both replications were very similar, this paper has chosen to present one set rather than using averages.

Two radiant flux indices were devised to characterize the amount and relative proportion of radiation components fluxing at the turf sites:

(a) Radiant flux index (RFI) = Direct solar radiation + Reflected solar radiation + Sky thermal radiation + Ground thermal radiation. It indicates the total amount of solar and terrestrial radiation entering and leaving a turf site on a daily basis.
(b) Radiant flux ratio (RFR) = (Direct solar radiation + Reflected solar radiation)/(Sky thermal radiation + Ground thermal radiation). It compares the solar radiant flux with the terrestrial radiant flux on a daily basis, indicating the relative magnitude of the two radiant components.

In addition, two thermal indices were developed to characterize the relative magnitude of the thermal energy content at the two sites:

(a) Aggregate thermal index (ATI) = $\Sigma(x - 30)/32$, using the top 32 highest temperature values recorded within a sample day (x) and 30 °C as threshold above which the temperature is considered as high for humid-tropical summer.
(b) Site ATI = Average of the five ATI values at the five measurement positions.

3. Results and discussion

3.1. Sampled days for three weather types

The microclimatic data were evaluated to select suitable days to represent sunny, cloudy and overcast conditions. The key weather parameters of the three chosen days in comparison with the urban weather station records are given in Table 2. At each site, the two replicate monitoring stations yielded similar results. Data from one station was used in the analysis; no attempt was made to average the two data sets.

Daily solar radiation input was the overarching factor of weather differentiation, with sunny day shooting above 20 MW m^{-2} which is about two-third of the maximum value received by the Earth (Gates, 2003), cloudy somewhat above 10 MW m^{-2}, and overcast below 10 MW m^{-2} (Table 2). The approximate relativity of incident solar energy of the three weather scenarios was 100:50:25. The government's main weather station is situated in the city core, originally with an urban fringe environs when it was established in 1883, which has since been surrounded by high-density urban sprawl. Wrapped around by built-up areas, the location registered less solar radiation and bright sunshine duration and lower temperatures than the well-exposed study sites.

The temperature records showed differences by weather type, with progressively lower maximum and minimum temperatures and narrower diurnal range in response to reduced solar radiation input (Table 2). Relative humidity (RH) indicated an inverse relationship with temperature, with higher temperature associated with lower RH. Sunny and cloudy days had meager rainfall respectively of 3.4 mm and 0.8 mm, whereas overcast had 7.0 mm.

3.2. Radiant flux on sunny day

On sunny day, the predominantly incoming solar irradiance had a small reflectance fraction (Fig. 4). Direct solar radiation received at NT was slightly higher than AT, respectively at 24.49 and 23.92 MW m^{-2} (Table 3). They differed mainly by reflected solar radiation, with three times higher albedo at NT reflecting 4.61 MW m^{-2} versus merely 1.52 MW m^{-2} at AT. Consequently, AT received 2.52 MW m^{-2} more net solar radiation than NT.

Terrestrial radiation contributed a large proportion of the radiant energy fluxes at both sites. It had considerably higher incoming and outgoing fluxes than solar radiation, bringing small outgoing net radiation (Fig. 4). The sky thermal radiation records at NT and AT were similar at above 38 MW m^{-2} (Table 3). Sky thermal radiation streamed down continuously in the 24-h cycle, with its

Table 2
Main weather data of the three sampled days with different weather conditions, respectively sunny, cloudy and overcast.

Location	Notation	Sample date (yyyymmdd)	Weather type	Solar radiation (MWm^{-2})[a]	Bright sunshine duration (h)[b]	Temperature[c]			Relative humidity (mean & range, %)	Rainfall (mm)
						Maximum (°C)	Minimum (°C)	Range (°C)		
Study site	SD	20140705	Sunny	24.49	9.8	34.4	28.3	6.1	80 (69–91)	3.4
Weather station[d]				23.97	9.9	33.8	28.9	4.9	76 (65–84)	1.5
Study site	CD	20140805	Cloudy	13.24	9.8	32.3	28.2	4.1	83 (73–88)	0.8
Weather station[d]				10.69	2.0	30.7	27.3	3.4	86 (78–96)	21.1
Study site	OD	20140707	Overcast	6.48	4.5	30.5	27.7	2.8	87 (78–92)	7.0
Weather station[d]				6.84	0.9	30.3	26.9	3.4	84 (77–91)	5.5

[a] Aggregate solar radiation received on the sampled day.
[b] Bright sunshine has an intensity ≥120 $W m^{-2}$.
[c] Air temperature taken at 1.5 m height at the natural turf site.
[d] The government's main weather station is situated on a small hill surrounded by dense built-up area.

Table 3
Components of the radiant energy budget by solar and terrestrial radiation on three weather-type days at natural and artificial turf sites.

Weather type[a]	Turf type[b]	Component of radiant energy budget (MWm^{-2})							Radiant flux index[c]	Radiant flux ratio[d]
		Direct solar radiation	Reflected solar radiation	Net Solar Radiation	Sky thermal radiation	Ground thermal radiation	Net thermal radiation	Net radiation		
Daily value:										
SD	NT	24.49	4.61	19.88	38.42	42.69	−4.27	15.61	110.21	0.36
	AT	23.92	1.52	22.40	38.81	47.08	−8.27	14.13	111.33	0.30
	NT-AT	0.57	3.09	−2.52	−0.40	−4.39	3.99	1.48	−1.12	0.06
CD	NT	13.24	3.08	10.16	38.76	41.57	−2.82	7.34	96.65	0.20
	AT	13.02	0.95	12.07	39.02	43.39	−4.38	7.69	96.38	0.17
	NT-AT	0.22	2.13	−1.91	−0.26	−1.82	1.56	−0.35	0.28	0.03
OD	NT	6.48	1.52	4.96	39.00	41.06	−2.06	2.90	88.06	0.10
	AT	6.05	0.59	5.46	39.05	41.70	−2.65	2.81	87.39	0.08
	NT-AT	0.43	0.93	−0.51	−0.05	−0.64	0.59	0.08	0.66	0.02
Daily difference:										
SD-CD	NT	11.25	1.53	9.72	−0.34	1.12	−1.46	8.27	13.56	0.16
	AT	10.90	0.57	10.33	−0.20	3.69	−3.89	6.44	14.96	0.13
SD-OD	NT	18.02	3.09	14.93	−0.58	1.63	−2.21	12.71	22.15	0.26
	AT	17.87	0.93	16.93	−0.24	5.38	−5.62	11.32	23.94	0.21
CD-OD	NT	6.76	1.56	5.20	−0.24	0.51	−0.75	4.45	8.59	0.10
	AT	6.97	0.36	6.61	−0.04	1.69	−1.73	4.88	8.98	0.09

[a] The three weather types are: SD for sunny, CD for cloudy, and OD for overcast. Their key weather parameters are summarized in Table 1.
[b] The two turf sites are: NT for natural turf, and AT for artificial turf.
[c] Radiant flux index = Direct solar + Reflected solar + Sky thermal + Ground thermal.
[d] Radiant flux ratio = (Direct solar + Reflected solar)/(Sky thermal + Ground thermal).

daily total exceeding direct solar radiation by a significant margin. Ground thermal radiation was higher than sky thermal radiation at both sites. Receiving the combined inputs of direct solar and sky thermal radiation, ground thermal radiation or terrestrial re-radiation operated continuously throughout the day to dominate the radiant environment. Absorbing more direct solar radiation, AT in turn emitted more ground thermal radiation than NT, being 47.08 MW m^{-2} versus 42.69 MW m^{-2}. Thus the net thermal radiation of AT was 3.99 MW m^{-2} higher than NT.

AT admitted more solar radiation and emitted more terrestrial radiation, bringing more total radiant flux than NT. The sensible heat flux at AT was also higher due to thermal transfer from hot synthetic turf materials by conduction and convection to near-ground air. In daytime, AT emitted considerably more longwave radiation than NT, whereas in nighttime the emissions were similar (Fig. 4b). The nocturnal similarity in ground thermal emission implied that AT was cooled rapidly after sunset to restrict lingering thermal effect in nighttime. Thus the differences in terrestrial radiant fluxes occurred mainly in daytime when the fields were more actively used. In daytime, players on the AT field are exposed to high levels of thermal radiation.

The RFI on sunny day stayed high at 110 at both sites (Table 3). The RFR indicated that about one third of the flux was contributed by solar radiation. Both sunny-day values were the highest amongst the three weather scenarios. For both sites, the solar fraction surplus was approximately equal to the site net radiation gain, and the terrestrial fraction experienced net loss due to ground thermal exceeding sky thermal radiation. The lower RFR at AT implied a radiant regime with more terrestrial radiation. The overall net incoming radiation at both sites was significant and contributed mainly by solar radiation (Fig. 4). At nighttime, outgoing net thermal radiation had small magnitude. Both sites experienced notable energy accretion on the sunny day.

3.3. Radiant flux on cloudy day

On cloudy day, solar radiation contributed relatively less to the total radiant energy fluxes at both sites (Fig. 5). Direct solar radiation received at both sites was similar at somewhat above 13 MW m^{-2} which was considerably below the sunny day (Table 3). However, they diverged by reflected solar radiation, with 3.08 MW m^{-2} at NT which was over three times of 0.95 MW m^{-2} at AT. Cloudy day albedo was higher than sunny day at NT, whereas it remained similarly low at AT, which admitted more net solar radiation.

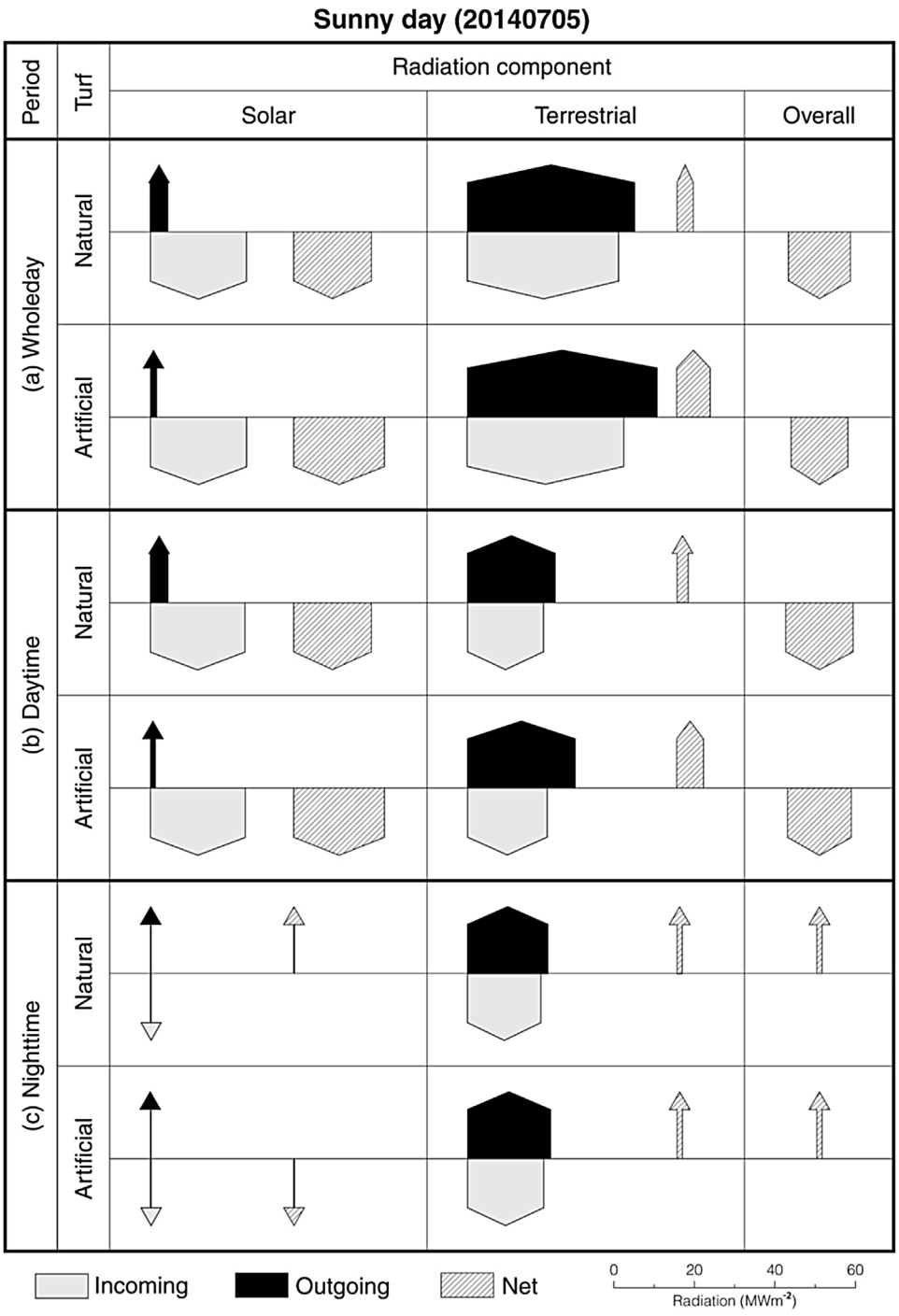

Fig. 4. The radiant energy fluxes at the natural and artificial turf sites on the sunny day (SD) in: (a) Wholeday; (b) Daytime; and (c) Nighttime.

Despite reduced direct solar radiation, sky thermal radiation on cloudy day was comparable to sunny day, with both sites receiving similar inputs. Ground thermal radiation dropped somewhat below sunny day, with AT maintaining a slightly higher level than NT. Ground thermal loss in daytime exceeded nighttime at AT, but less so than sunny day (Fig. 5b). Similar to sunny day, at AT more solar radiation gain was offset by more terrestrial loss. As AT released more of its stored heat than NT, its net thermal radiation is 1.56 MW m^{-2} higher.

Despite reduced solar radiation input, the two sites differed by lower reflectivity and higher ground thermal radiation at AT. The radiant and sensible energy budgets at AT had more fluxes than NT. The higher thermal fluxes at AT occurred mainly in daytime, during which players are exposed to the thermal impacts (Fig. 5).

The RFI on cloudy day dropped down to around 96 for both sites, mainly due to trimmed direct solar input (Table 3). The RFR of 0.20 for NT and 0.17 for AT was notably below sunny day. Again, AT was more affected by a stronger terrestrial component than NT.

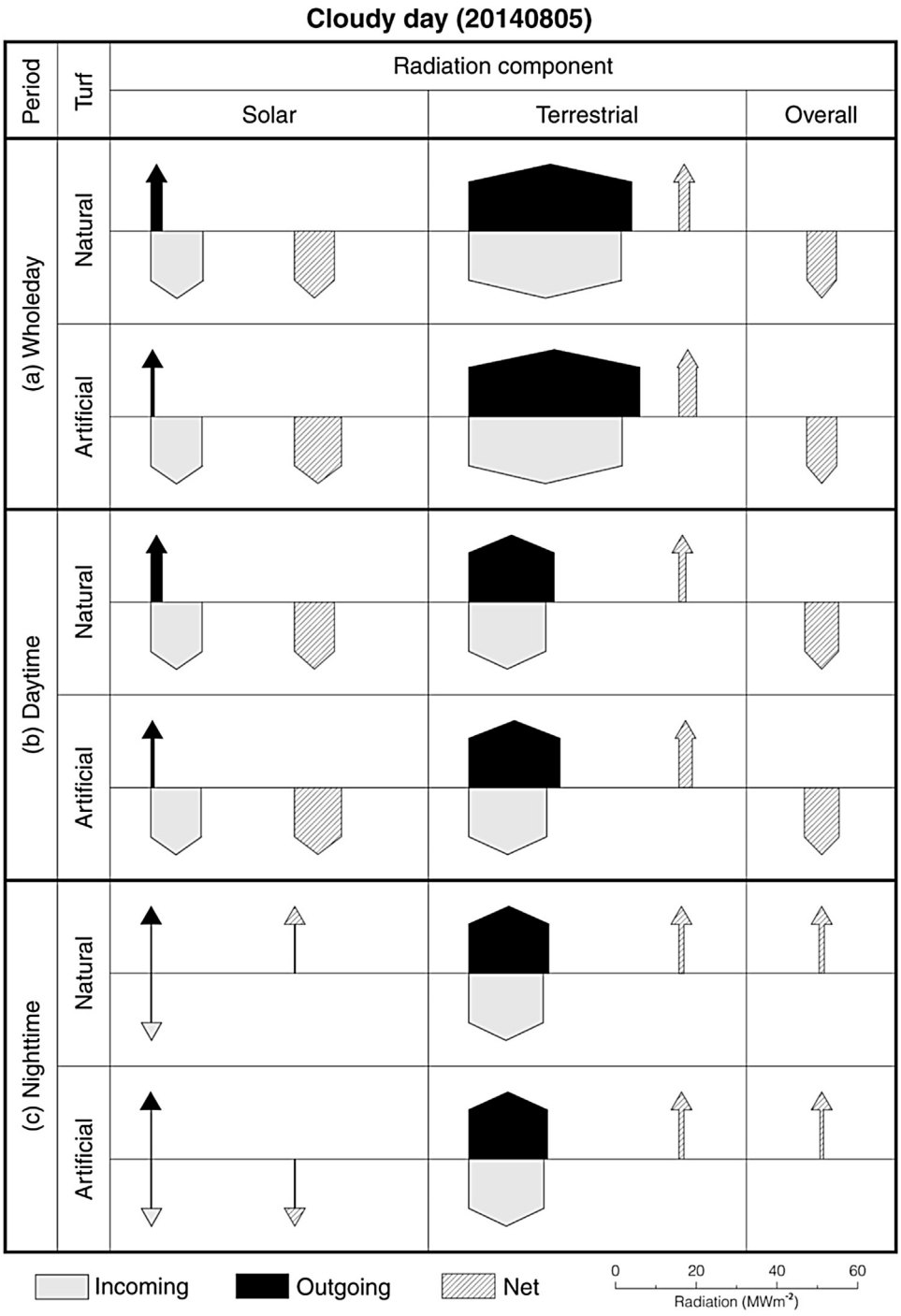

Fig. 5. The radiant energy fluxes at the natural and artificial turf sites on the cloudy day (CD) in: (a) Wholeday; (b) Daytime; and (c) Nighttime.

3.4. Radiant flux on overcast day

On overcast day, solar radiation fluxes shrank considerably whereas terrestrial radiation fluxes remained rather high and similar to cloudy day (Fig. 6). Direct solar radiation input dropped down to around 6 MW m^{-2} at both sites (Table 3). Despite the subdued solar radiation input, the reflectivity differential between NT and AT stayed similar to cloudy day. Reflected solar radiation at AT was still 0.93 MW m^{-2} lower than NT despite the reduced solar radiation input.

Sky thermal radiation on overcast day was slightly higher than sunny and cloudy days, shooting just above 39 MW m^{-2}. Ground thermal radiation was not dampened by the overcast condition, as it was only slightly lower than cloudy day. However, the difference between the two sites was depressed, with AT merely 0.64 MW m^{-2} higher than NT. The net thermal radiation of the two fields tended to converge, dropping down to merely around 3 MW m^{-2}.The reduced solar radiation input effectively suppressed the thermal differences between the two sites. Players in daytime continued to be washed by considerable thermal radiation (Fig. 6). However, unlike sunny and cloudy days, in daytime AT did not experience notably more thermal energy fluxes than NT.

The RFI at around 88 at both sites fell below cloudy day by about 9 units (Table 3). The RFR sank down to 0.10 and 0.08, indicat-

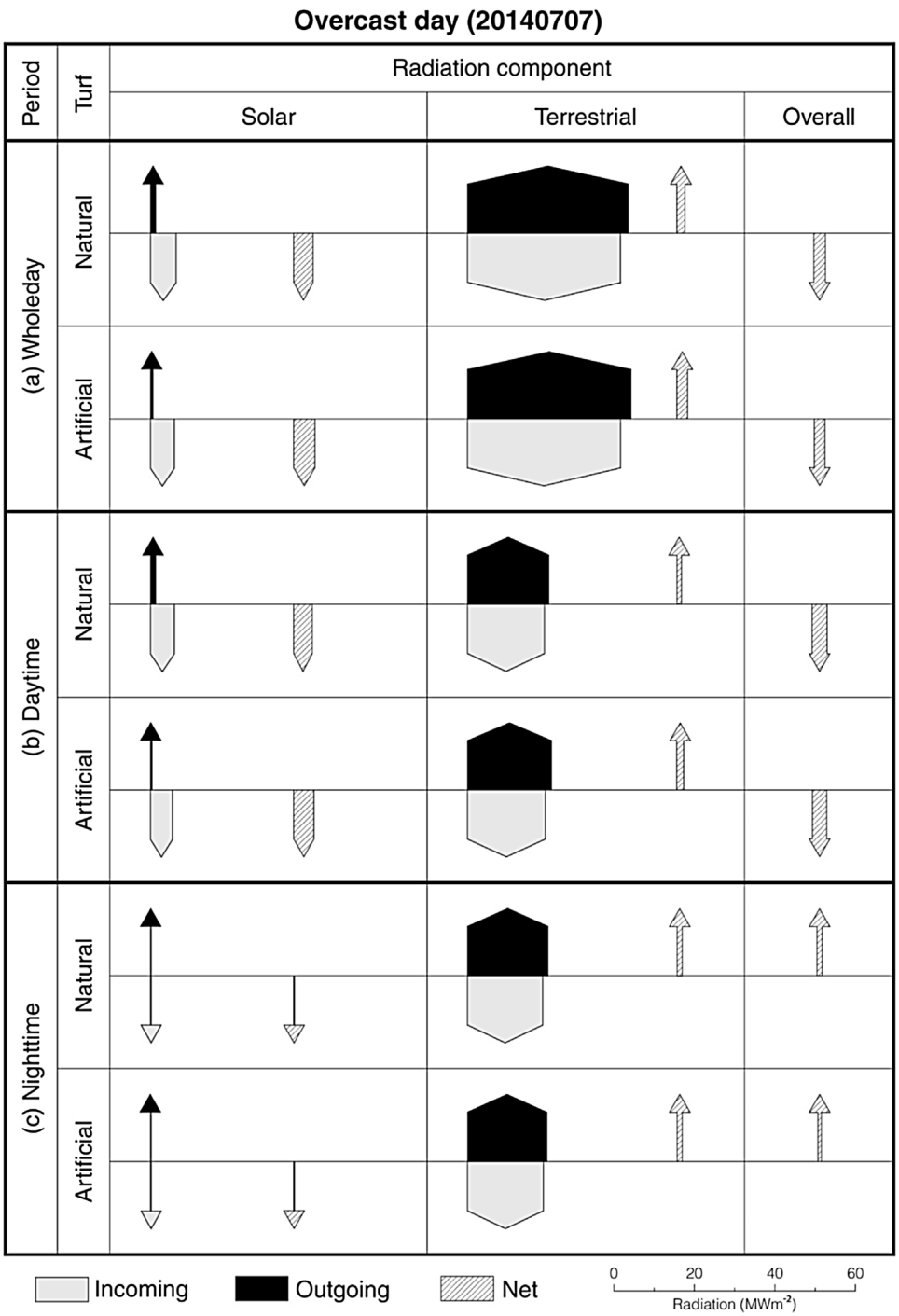

Fig. 6. The radiant energy fluxes at the natural and artificial turf sites on the overcast day (OD) in: (a) Wholeday; (b) Daytime; and (c) Nighttime.

ing strong influence of terrestrial radiation. Despite shrinking of solar radiation components, terrestrial radiant flux remained quite rigorous to dominate the radiant energy budget.

3.5. *Temperature profile on sunny day*

On sunny day at 0800 h, NT and AT temperatures were similar at different heights, with AT only slightly warmer at turf surface (Fig. 7a). As early as 1000 h, AT turf surface shot up to 54.5 °C compared with merely 32.5 °C at NT (Fig. 7b). At AT, the moderate morning insolation could heat up rather quickly the surface material early in the day. Conduction and convection transferred the heat stored in AT material to warm adjacent substrate (45.0 °C) and 15-cm air (38.2 °C). The warming effect could be felt at 150 cm which was 2.9 °C warmer than NT.

By noon, AT turf surface temperature peaked at 72.4 °C indicating swift thermal response to peak solar radiation input with little time lag (Fig. 7c). The stored heat was transmitted effectively mainly by conduction downwards to warm substrate to 70.4 °C. The similarity in material temperature indicated efficient heat transfer from surface to subsurface rubber-infill materials. Air temperature was lifted to 42.5 °C at 15 cm, and 36.9 °C at 50 cm. Meanwhile, NT temperature was only raised a few degrees higher than ambience

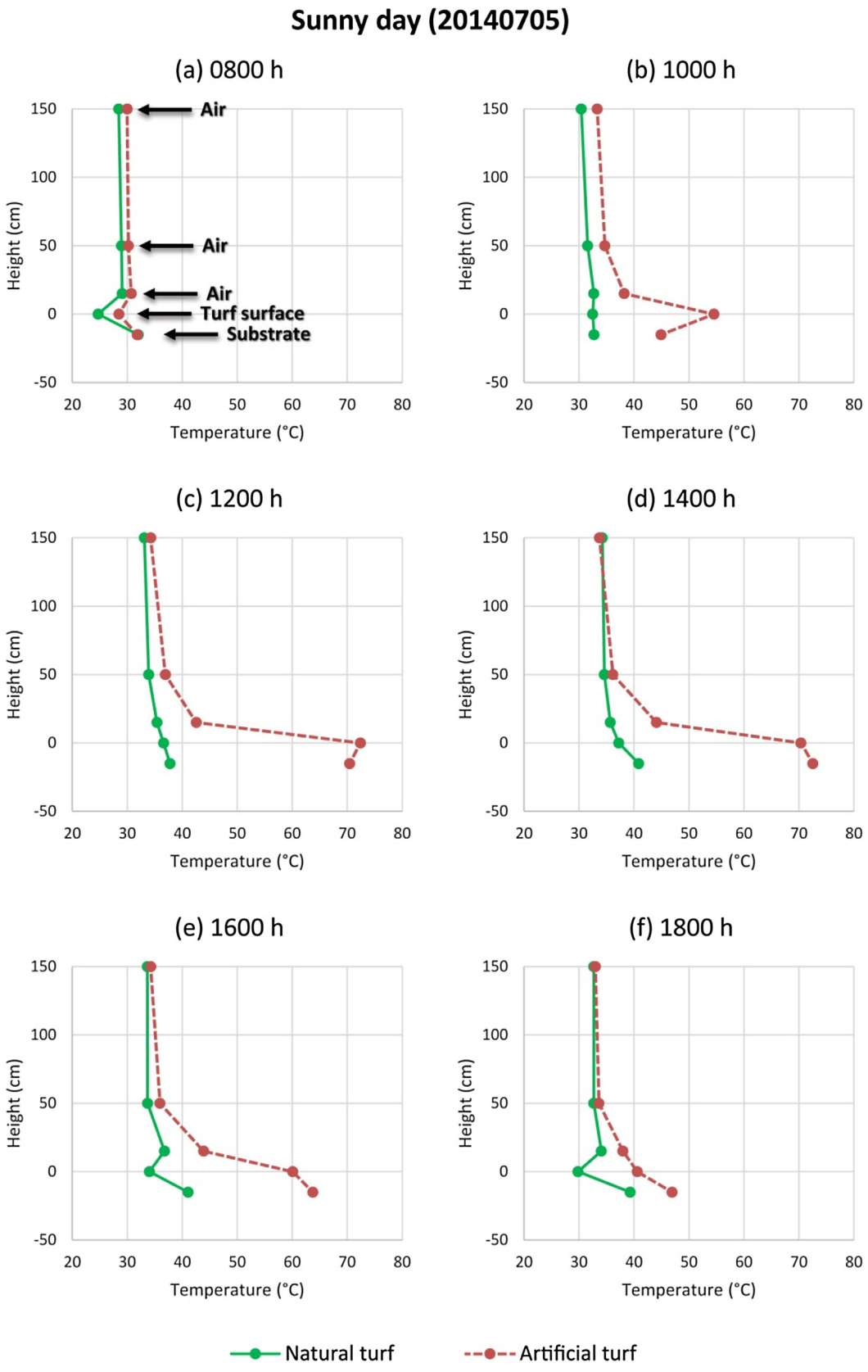

Fig. 7. Vertical temperature profiles from 150 cm height to substrate at six times on the sunny day (SD) comparing natural and artificial turf sites.

denoted by 150 cm (33.0 °C), with maximum temperature attained in substrate (37.8 °C) which was slightly warmer than turf surface (36.6 °C).

At 1400 h, AT substrate recorded the highest temperature at 72.5 °C to surpass turf surface at 70.4 °C. At 15 cm, air temperature continued to rise to 44.1 °C (Fig. 7d). At 50 cm and 150 cm, however,

air temperature began to drop slightly. In comparison, NT temperatures continued to rise slightly at all five levels. Its turf surface attained the daily peak (37.2 °C), indicating a time lag in relation to solar-input peak. The NT substrate was cooler than AT by 33.2 °C, and turf surface by 31.7 °C.

At 1600 h, solar radiation input began to wane, leading to fast cooling of AT turf surface to 60.1 °C and substrate to 63.7 °C. In tandem, air temperatures at 15 cm and 50 cm also dropped slightly (Fig. 7e). At NT, substrate temperature continued to rise to the daily maximum of 41.0 °C. This result indicated establishment of the *thermal-mass effect* due to the high specific heat of soil moisture leading to *thermal inertia*, hence delayed peak temperature and sustained high temperature.

At 1800 h, close to sunset, drastic cooling occurred at AT turf surface and substrate, bringing notable drop of respectively 19.5 °C and 16.8 °C in comparison with 1600 h (Fig. 7f). The prompt temperature response to dwindling solar radiation input echoed poor *heat storage capacity* of AT materials. At NT, substrate cooled slower than turf surface, suggesting the operation of thermal inertia in the moist soil material. Air temperatures at 150 cm and 50 cm of the two sites nearly converged. Rapid cooling of AT material and air in late afternoon implied that the field experienced a plunge in heat-stress problems soon after sunset.

Key temperature records and occurrence times were summarized in Table 4. Maximum temperatures occurred in the afternoon, and as early as 1300 h at both turf surfaces (Table 4a). At NT, the maximum temperature decreased with height. At AT, maximum temperature of turf surface was the same as substrate. Maximum temperatures of AT exceeded NT by 32.5 °C and 36.5 °C respectively at turf surface and substrate, whereas air temperatures were higher by 6.5 °C at 15 cm, 2.3 °C at 50 cm, and similar at 150 cm. The two sites had similar minimum temperatures, except substrate with AT warmer than NT by 3.4 °C (Table 4b).

The AT diurnal temperature range reached 50.7 °C at turf surface and 45.4 °C at substrate, exceeding NT by 36.5 °C and 35.9 °C (Table 4c). The differences shrank to 6.5 °C at 15 cm, 2.4 °C at 50 cm, and merely 0.7 °C at 150 cm. The ATI had the largest difference between the two sites at turf surface (28.8) and substrate (24.7). They were notable lower for air temperatures (Table 4d). Site ATI of AT was very high at 17.80 vis-à-vis NT with only 5.42. The thermal ambience to players was notably more stressful at AT. AT materials were warmed well above NT's due to a combination of inherent and predisposing factors, including low albedo, low specific heat of the plastic fibers (Professional Plastics, 2015) and rubber-granule infill materials (Nah, Park, Cho, Chang, & Kaang, 1999), and low moisture content which suppresses the substrate thermal capacity. More solar radiation absorbed by AT turf surface was transformed to sensible heat. With limited thermal capacity, solar radiation can notably raise material temperature at a fast rate with hardly any time lag. With little moisture in the emulated grass-leaf fibers and infill materials, evaporative cooling was restricted and little heat could be stored in feeding the thermal-mass effect. The heated materials in turn can emit longwave ground radiation to increase the radiation load. The limited thermal storage is a two-edged sword, as it could also allow relatively fast cooling. The intense radiant-energy regime in tropical sunny daytime could present acute heat stress to athletes (Larsen et al., 2007). Approaching and soon after sunset, however, AT turf surface and substrate could cool down rather quickly to dampen the heat-stress risk.

In contrast, NT had higher albedo, higher specific heat of grass tissues, and mineral soil with porosity partly filled by water to raise specific heat (Abu-hamdeh, 2003). These compositions and properties fostered evapotranspiration to bring latent heat cooling (Jayalakshmy and Philip, 2010) and imparted a higher thermal capacity to retard the rate and range of temperature rise and fall. Therefore, NT could not heat up to a high level, and would warm up and cool down at a relatively slower pace.

3.6. Temperature profile on cloudy day

The reduced solar radiation input brought notable temperature responses at both sites (Fig. 8). At 0800 h, the two curves nearly overlap except turf surface which was already warmer at AT by 5.6 °C (Fig. 8a). The NT turf surface was able to cool overnight with the help of evaporation to 26.7 °C, the lowest of the five levels, to create a small temperature inversion near the ground. The dry AT materials could not benefit from evaporative cooling at night. The feeble solar energy in early morning began to initiate mild warming at AT. In nighttime, ground thermal radiation loss was only slightly higher than sky thermal radiation gain, hence its overnight cooling effect at turf surface and substrate was limited.

At 1000 h, the morning solar radiation input managed to trigger warming at AT turf surface and substrate, quickly pushing the temperatures respectively by 11.5 °C and 9.5 °C above NT (Fig. 8b). Air temperature at 15 cm was raised by 1.3 °C, but higher up the warming effect did not bring notable differences between the two sites. The NT turf surface remained cooler than other elevations to sustain the ground-hugging temperature inversion. At noon, AT temperatures climbed quickly to 52.7 °C at turf surface and 54.2 °C at substrate. They were close to the maximum of the day, departing notably from 150-cm air temperature at 31.1 °C (Fig. 8c). The maximum temperature of 65.8 °C was reached at 1130 h (Table 4). Meanwhile, NT temperatures stayed relatively low, reaching 33.0 °C at turf surface and 35.1 °C at substrate. This is the only time when the near-ground temperature inversion was suppressed. Warming due to solar irradiance was more or less nullified by evapotranspiration cooling to maintain a relatively cool turf surface and substrate. Nevertheless, the rate of evapotranspiration cooling was not adequate to retain the temperature inversion at turf surface. The intensity of insolation on the cloudy day, even at noontime, was unable to exceed the *energy balance tipping-point* (EBT) between the two opposing forces of warming vis-à-vis cooling. At AT, the lower albedo, more incident insolation and lack of latent heat dissipation jointly raised turf surface and substrate temperatures. The maximum temperature of the day was reached around noon to synchronize with maximum solar radiation input.

At 1400 h, with decline in direct solar radiation input, the two sites expressed different responses (Fig. 8d). At NT, the temperature inversion at the turf surface was re-established at 26.7 °C, reflecting that the energy budget has dropped further below the EBT. Meanwhile, soil moisture in the substrate was able to nurture the thermal mass and raise its temperature to 35.7 °C. At AT, the reduced insolation brought fast drop in turf surface temperature to 38.3 °C. The substrate temperature dropped but was kept at 47.6 °C due to thermal inertia.

At 1600 h and 1800 h, the solar radiation input subsided, and the turf surface and substrate temperatures at both sites dropped down to several degrees above air at 150 cm (Fig. 8e and f). NT turf surface continued to sustain the small temperature inversion. The AT temperature at turf surface (respectively 35.0 °C and 31.2 °C) stayed at 5–6 °C above NT, and at 15 cm 1–2 °C above NT. For sports turf use, from 1600 h onwards, the heat stress at AT was not notably higher than NT. It signified that on summer cloudy days from mid-afternoon onwards, AT could lapse into a relatively *heat-safe period* for players. This finding hints that games could be scheduled to avoid the hottest periods, and they could be shifted to times and weather conditions with relatively lower temperature (Grundstein et al., 2014; Kajiwara et al., 2005). The summer cloudy day offers a wider window to meet such demands.

For maximum temperature, despite the reduced solar radiation input, AT still exceeded NT by 29.7 °C at turf surface and 22.5 °C at

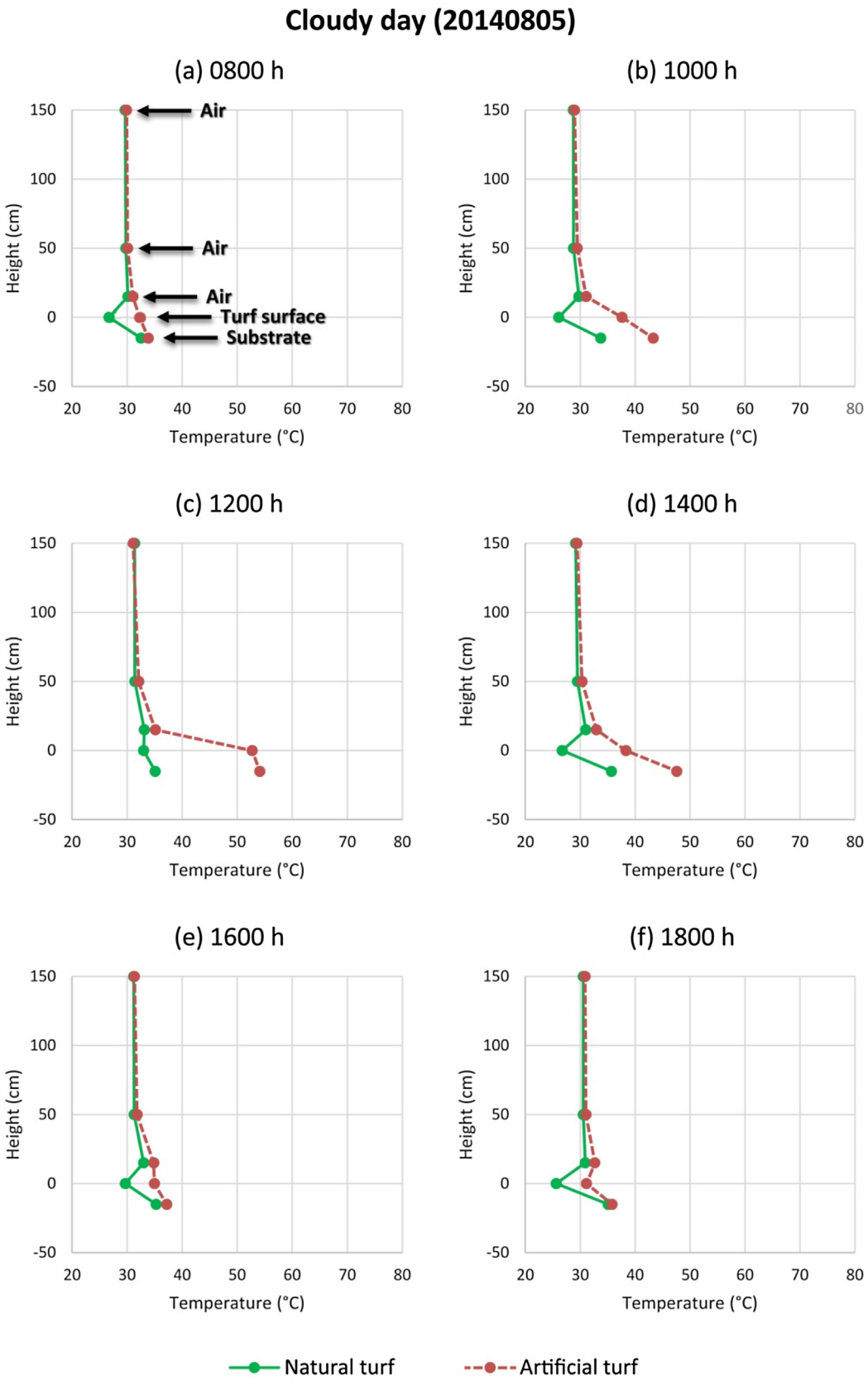

Fig. 8. Vertical temperature profiles from 150 cm height to substrate at six times on the cloudy day (CD) comparing natural and artificial turf sites.

Table 4
Selected temperature records at the natural and artificial turf sites respectively on sunny, cloudy and overcast sampled days.

Temperature attribute	Natural turf (NT)			Artificial turf (AT)			AT − NT[c]		
	Sunny 20140705	Cloudy 20140805	Overcast 20140707	Sunny 20140705	Cloudy 20140805	Overcast 20140707	Sunny 20140705	Cloudy 20140805	Overcast 20140707
(a) Maximum temperature:									
Air at 150 cm (°C)	34.4	32.3	30.5	34.4	33.6	32.4	−0.1	1.3	1.9
Occurrence time (h)	1630	1330	0645	1500	1130	1100	−0130	−0200	0415
Air at 50 cm (°C)	34.6	32.4	31.0	36.9	34.7	33.5	2.3	2.3	2.6
Occurrence time (h)	1400	1330	1100	1500	1130	1100	0100	−0200	0000
Air at 15 cm (°C)	37.6	34.7	32.4	44.1	38.4	37.8	6.5	3.8	5.4
Occurrence time (h)	1545	1330	1100	1400	1130	1100	−0145	−0200	0000
Turf surface (°C)	37.3	36.1	31.6	73.8	65.8	52.5	36.5	29.7	20.9
Occurrence time (h)	1315	1130	1100	1300	1130	1100	−0015	0000	0000
Substrate at 6 mm depth (°C)	41.4	35.7	34.6	73.8	58.2	49.6	32.5	22.5	15.0
Occurrence time (h)	1515	1400	1130	1315	1145	1115	−0200	−0215	−0015
(b) Minimum temperature:									
Air at 150 cm (°C)	28.3	28.2	27.7	29.0	28.2	28.1	0.6	−0.1	0.4
Occurrence time (h)	0915	0500	0930	0400	0230	1200	−0515	−0230	0230
Air at 50 cm (°C)	28.8	28.0	27.9	28.7	27.9	27.9	0.0	−0.1	0.0
Occurrence time (h)	0400	0315	2315	0400	0415	2315	0000	0100	0000
Air at 15 cm (°C)	28.3	27.5	27.5	28.2	27.6	27.4	0.0	0.1	−0.1
Occurrence time (h)	0415	0415	2315	0415	0415	2315	0000	0000	0000
Turf surface (°C)	23.2	22.0	22.7	23.2	22.8	23.1	0.0	0.7	0.4
Occurrence time (h)	0415	0415	2345	0415	0415	2315	0000	0000	−0030
Substrate at 6 mm depth (°C)	31.8	32.5	31.3	28.4	28.2	27.5	−3.4	−4.2	−3.7
Occurrence time (h)	0700	0715	2345	0430	0430	2330	−0230	−0245	−0015
(c) Diurnal temperature range:									
Air at 150 cm (°C)	6.12	4.06	2.79	5.40	5.43	4.28	−0.7	1.4	1.5
Air at 50 cm (°C)	5.83	4.44	3.08	8.19	6.83	5.67	2.4	2.4	2.6
Air at 15 cm (°C)	9.38	7.17	4.90	15.86	10.87	10.43	6.5	3.7	5.5
Turf surface (°C)	14.15	14.10	8.92	50.70	43.05	29.41	36.5	28.9	20.5
Substrate at 6 mm depth (°C)	9.55	3.25	3.38	45.40	30.00	22.07	35.9	26.8	18.7
(d) Aggregate thermal index (ATI)[a]:									
Air at 150 cm (°C)	3.29	1.03	−0.21	3.56	1.25	0.27	0.3	0.2	0.5
Air at 50 cm (°C)	3.54	1.14	−0.14	5.61	1.83	0.51	2.1	0.7	0.6
Air at 15 cm (°C)	5.53	2.31	−0.02	11.57	4.51	1.59	6.0	2.2	1.6
Turf surface (°C)	4.97	0.32	−3.34	33.78	13.66	3.68	28.8	13.3	7.0
Substrate at 6 mm depth (°C)	9.78	5.23	3.80	34.48	14.93	6.70	24.7	9.7	2.9
Site ATI[b]	5.42	2.01	0.02	17.80	7.24	2.55	12.4	5.2	2.5

[a] Using the top 32 values of the sampled day and 30 °C as threshold temperature, ATI = Σ(x − 30)/32.
[b] Site ATI is the average of the five ATI values at individual measurement positions.
[c] The difference in timing (AT-NT) is expressed as hhmm, e.g. 0545 means AT 5 h 45 min ahead of NT, and −0545 mean behind.

substrate (Table 4a). The inherent difference in thermal properties and behaviors of the two turf sites sustained a wide divergence in mainly material temperatures. For minimum temperature, the two sites were similar except at substrate where NT was warmer than AT by 4.2 °C (Table 4b). This result verified the existence of thermal mass and hence thermal inertia at NT substrate due to presence of water with high specific heat.

The diurnal temperature ranges at AT were considerably higher than NT (Table 4c). Reduction in solar radiation input, however, had suppressed the inter-site differences to 28.9 °C at turf surface and 26.8 °C at substrate. ATI values were considerably depressed on cloudy day, and the differences between AT and NT had been reduced to around 10 at the turf surface and substrate (Table 4d). Site ATI was depressed considerably to 7.24 at AT in comparison with 2.01 at NT.

3.7. Temperature profile on overcast day

On overcast day, direct solar radiation peaked at 1100 h, and dropped to only about 40–60 W m^{-2} thereafter. The 7 mm of rainfall happened around 1100 h to reduce heat accumulation towards noontime. The temperature profiles faithfully reflected this radiant energy pattern (Fig. 9). At 0800 h, the two sites had similar temperature patterns except lingering of turf surface temperature inversion at NT (Fig. 9a). Notable warming of turf surface and substrate occurred only at 1000 h at AT, lifting temperatures respectively to 41.3 °C and 42.6 °C (Fig. 9b). Despite the much subdued solar radiation input, AT air temperatures at 150 cm, 50 cm and 15 cm were all warmed to about 2–4 °C above NT. In the remainder of the day, the temperature curves of the two sites nearly converged even at noon (Fig. 9c–f). Both fields would not incur excessive heat stress for players on the overcast day.

Despite the weak solar radiation input, the overcast day maintained a rather high maximum temperature at AT of 52.5 °C at turf surface and 49.6 °C at substrate (Table 4a). The small amount of sunshine was able to heat up AT materials. In contrast, at NT the material maximum temperatures were only a few degrees above 150-cm value. High specific heat of grass tissues and soil could resist temperature rise and compress diurnal temperature amplitude under the low solar-radiation regime. For minimum temperature, NT and AT were similar except that NT substrate was warmer by 3.7 °C (Table 4b).

The diurnal temperature range of AT exceeded NT at all measurement levels (Table 4c). Despite the feeble solar irradiance, AT turf surface and substrate were respectively 20.5 °C and 18.7 °C higher than NT. The differences were due to higher AT maximum rather than lower minimum. Both sites experienced significant drop in ATI, being more so at NT (Table 4d). Site ATI at NT dropped down to merely 0.02 whereas AT sustained 2.55.

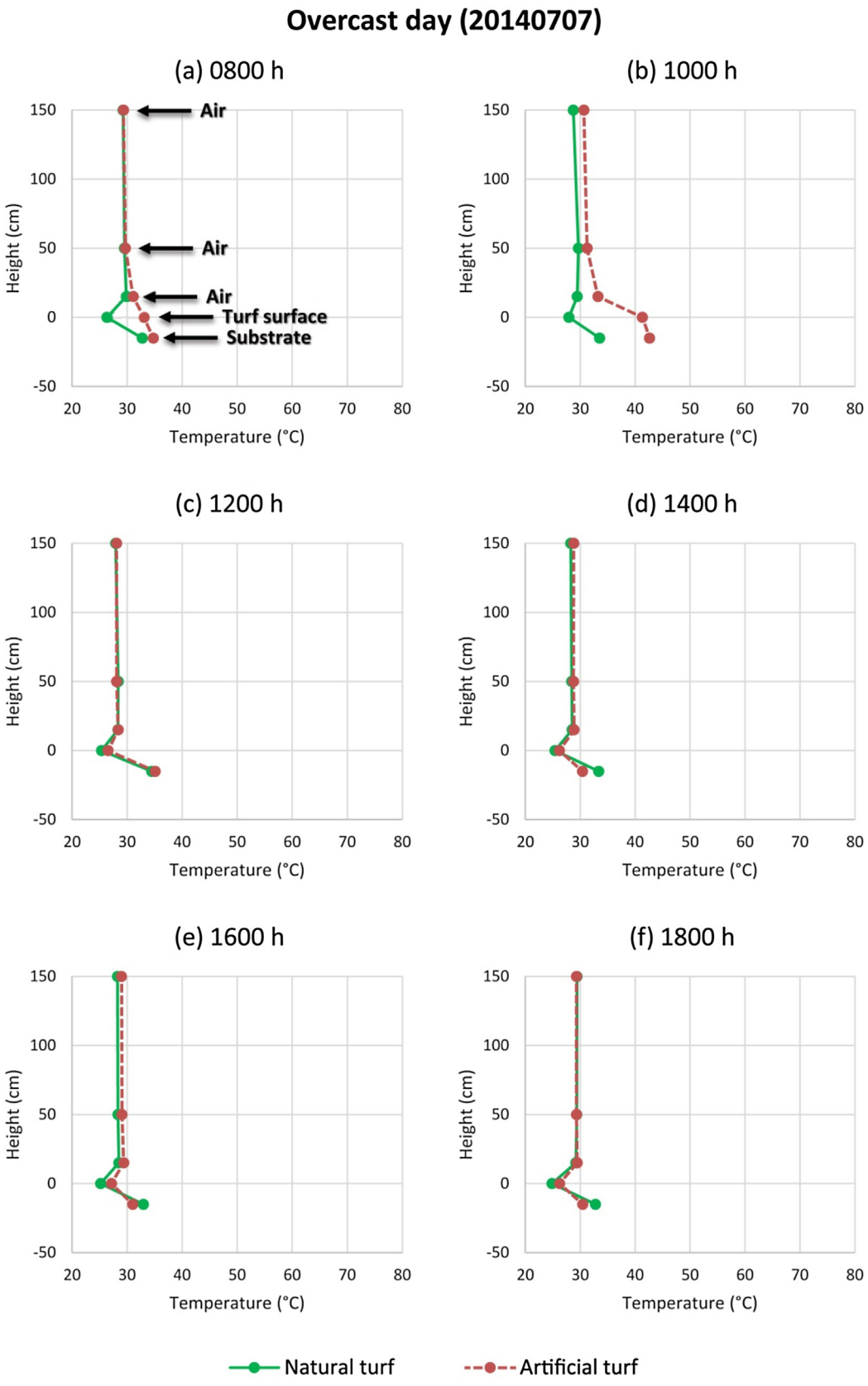

Fig. 9. Vertical temperature profiles from 150 cm height to substrate at six times on the overcast day (OD) comparing natural and artificial turf sites.

4. General discussion and conclusion

Partitioning the multiple energy pathways at the turf sites could ascertain the radiant and sensible-heat energy budgets with important bearing on their thermal regimes. Solar radiation in the tropical summer is dominated by strong incoming irradiance with a small outgoing (reflected) portion. Cloudy day considerably attenuates solar radiation input to about half, and overcast day about a quarter. Terrestrial radiation, on the other hand, has sizeable sky thermal radiation influx as well as ground thermal radiation efflux components, occurring continually in both daytime and nighttime. They are less affected by weather conditions in the absence of rainfall. Despite drastic reduction in solar gain from sunny to cloudy and overcast days, incoming and outgoing terrestrial radiation in daytime and nighttime are sustained at a high level. By total energy flux on a daily basis, a considerably larger amount of thermal radiant energy than solar energy is fluxed in the near-ground ambience of the turf sites.

The two components of the radiant energy budget offer the crucial determinants of NT and AT thermal performance. For shortwave radiation, AT has a lower solar reflectance than NT to increase its solar gain. The differential is maintained in relative terms regardless of weather condition. For longwave radiation, AT has higher ground thermal or terrestrial re-radiation than NT to increase its thermal loss and hence thermal load on players. The sunny day has the highest ground thermal emission, followed by cloudy and overcast. AT absorbs more solar radiation and releases more thermal radiation to generate a high energy-content ambience. AT in effect serves as an efficient processor of solar energy, receiving more, converting promptly more to sensible heat, and shifting more heat to the near-ground environment. The relative proportions of the main radiant energy components play key roles in the divergent thermal expression of the two turf sites.

The total radiant flux index (RFI) presents an aggregate quantitative measure of the amount of radiant energy passing through the fields. The RFI of the three weather days is on average 100:87:80 (sunny:cloudy:overcast), indicating progressive reduction in radiant flux contents (Table 3). In comparison, the corresponding net radiation is on average 100:50:20. The discrepancies between these two numerical sequences imply that despite the drastic curtailment of insolation, terrestrial radiation fluxes continue to operate intensely to support relatively high RFI values. For a given weather day, the two turf sites have similar RFI as well as net radiation values. It implies that NT admits less radiant energy and emits less; AT admits more and emits more. This finding signifies the fundamental basis of the differential thermal behavior of the two fields.

In contrast, the relative contributions of solar and terrestrial radiation, measured by radiant flux ratio (RFR), differ greatly between the weather days (Table 3). For NT, it ranges from 0.36 (sunny) to 0.20 (cloudy) and 0.10 (overcast). For AT, the respective values are consistently lower at 0.30, 0.17 and 0.08. The results signify substantial increase in terrestrial radiation components along the weather sequence. The consistently lower RFR of AT than NT indicates that greater terrestrial components are conducive to material and air warming. Ground thermal radiation is higher than sky thermal radiation for all weather days. It indicates the importance of outgoing infrared radiation in tandem with conduction and convection in releasing AT stored sensible heat. Moreover, the ground thermal radiation at AT is higher than NT on days with more solar radiation inputs (sunny and cloudy), but it is similar on overcast day. Thus strong insolation is necessary to drive more ground thermal emission at AT than NT to accentuate inter-site divergence in thermal regimes. This phenomenon could be labelled *solar-induced thermal divergence*, which diminishes in effect with decline in insolation.

Acquiring more solar radiation due to lower albedo presents the predisposing and necessary but not sufficient condition to induce drastic rise in AT material (turf surface and substrate) temperature. The thermal properties and behaviors of AT materials substantially account for the heat absorption, retention, transmission, emission and release. The plastic imitation grass blades (piles) and the black rubber granules (infill) have low specific heat and little moisture-holding capacity. Upon absorbing solar energy, they are quickly heated up with little time lag, bringing unusually high maximum temperature and wide diurnal temperature amplitude. In contrast, NT with higher specific heat and moisture content to sustain evapotranspiration cooling, suppresses warming, creates thermal mass effect, generates thermal inertia, delays warming, but also postpones cooling. Thus NT has notably lower maximum temperature and narrower diurnal temperature amplitude.

The sunny day heats AT materials to over 70 °C, attained at noontime and maintained in the early afternoon. The retained heat is in turn transferred to near-ground air by conduction and convection to raise air temperature to above 40 °C. In turn, the heated surface emits a large quantity of infrared radiation. The AT site is immersed in an ambience of intense radiant fluxes composing of direct solar radiation, incoming and outgoing infrared radiation, as well as strong sensible-heat streams emanating from the hot AT material. Their joint impact on athletes can induce heat stress to exceed the safety threshold and harm their health and performance. The daytime period is particularly heat-risky and should be avoided for games and practices.

On sunny day, the confined heat reservoir at the AT field, however, demonstrates an easy-come-easy-go phenomenon. Fast warming in the early part of the day is accompanied by fast cooling in late afternoon. High emissivity in the infrared spectrum feeds efficient heat dissipation by ground thermal radiation, thus allowing relatively safe use by players soon after sunset. In contrast, NT suppresses and delays warming, postpones cooling, and extends gentle warming over a longer period. The maximum temperature at the NT turf surface stays in the thirties, which is only a few degrees above the 150-cm ambient air temperature. The effective latent heat dispersion by evapotranspiration at NT creates a small temperature inversion near the turf surface outside the hottest period around noontime.

On cloudy day, solar irradiance is drastically curtailed, but thermal radiation components do not experience a corresponding decline. The AT turf surface can still be heated to the maximum of 65.8 °C shortly before noon. Part of the stored heat is transferred to near-ground air, warming it to about 5 °C degrees higher than the 150-cm level. In daytime, ground thermal emission still exceeds sky thermal. A notable amount of infrared radiation is emitted by the hot ground at a lower quantity than sunny day. From 1600 h, the subsidence in insolation induces prompt cooling to dampen turf surface temperature. At 1800 h the turf surface temperature drops down to 31.2 °C which is not notably warmer than NT. Overall, summer cloudy day is still too hot from late morning to late afternoon for sports events. However, it could cool down to an acceptable level from late afternoon onwards. Games and practices should avoid the hottest circum-midday periods and be accommodated in the wider heat-safe window.

The overcast day notably depresses solar radiation input and brings small collateral reduction in terrestrial radiant fluxes. Sky thermal and ground thermal radiation components still remain rather high which are comparable to cloudy day. The inter-site differential in terms of sky thermal and ground thermal radiation components shrinks notably. AT still emits more infrared radiation than NT, and it sustains a higher maximum temperature above 50 °C for a short period. For most of the day, the two fields are similar in terms of human thermal comfort to players, thus offering flexibility to schedule matches or practices. The findings clarify the regula-

tion of the thermal regimes at natural and artificial turf fields by solar and terrestrial radiant energy fluxes under different weather conditions in summer. The changes in radiation and temperature in the diurnal cycle, and the relationships between the two attributes, have been ascertained by the detailed field-experiment data. The analysis can improve understanding of the complex relationships amongst the key factors and the associated processes leading to the inordinate temperature elevation at AT sites. The daily marches of radiation and temperature provide an objective basis to identify the heat-safe windows and to optimize scheduling of events to avoid heat-stress health impacts.

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Health Impacts of Artificial Turf: Toxicity Studies, Challenges, and Future Directions

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Abstract

Many communities around the country are undergoing contentious battles over the installation of artificial turf. Opponents are concerned about exposure to hazardous chemicals leaching from the crumb rubber cushioning fill made of recycled tires, the plastic carpet, and other synthetic components. Numerous studies have shown that chemicals identified in artificial turf, including polycyclic aromatic hydrocarbons (PAHs), phthalates, and per- and polyfluoroalkyl substances (PFAS), are known carcinogens, neurotoxicants, mutagens, and endocrine disruptors. However, few studies have looked directly at health outcomes of exposure to these chemicals in the context of artificial turf. Ecotoxicology studies in invertebrates exposed to crumb rubber have identified risks to organisms whose habitats have been contaminated by artificial turf. Chicken eggs injected with crumb rubber leachate also showed impaired development and endocrine disruption. The only human epidemiology studies conducted related to artificial turf have been highly limited in design, focusing on cancer incidence. In addition, government agencies have begun their own risk assessment studies to aid community decisions. Additional studies in *in vitro* and *in vivo* translational models, ecotoxicological systems, and human epidemiology are strongly needed to consider exposure from both field use and runoff, components other than crumb rubber, sensitive windows of development, and additional physiological endpoints. Identification of potential health effects from exposures due to spending time at artificial turf fields and adjacent environments that may be contaminated by runoff will aid in risk assessment and community decision making on the use of artificial turf.

Graphical Abstract

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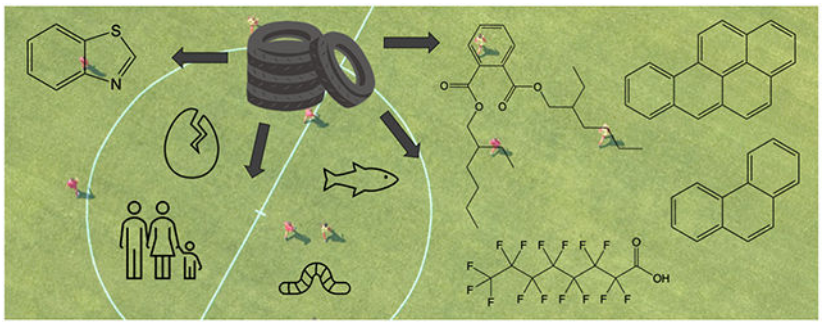
Conflict of Interest Statement

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.



Keywords

artificial turf; crumb rubber; endocrine disruption; polyaromatic hydrocarbons; phthalates; perfluoroalkyl substances; environmental exposure; risk assessment

Introduction

A key feature of modern society is the drive to optimize and modify our environment with technological advances to improve our quality of life and adapt to changing environmental conditions. However, many such modifications come with increased risk to the natural environment and our own health. Replacing natural grass fields with artificial turf is one example of an “improvement” with unexplored health risks.

Artificial turf is a carpet of synthetic fibers that imitates the appearance of a natural grass field. It is widely used for recreational and professional athletics in the US and Europe. In 2020, the value of the artificial turf market was estimated at $2.7 billion and is experiencing massive growth with the market expected to more than double by 2027, with demand mostly driven by athletics and expanding to markets outside of the US and Europe (Industry Research 2021). As artificial turf is typically installed in areas that had previously been covered with plant life, this increase in coverage of the Earth’s surface with synthetic materials that increase runoff and have been shown to cause heat island effects has important implications for climate change (Shi and Jim 2022). Proponents of artificial turf prefer the durable polymer surface to optimize limited playing space and time. Grass fields require maintenance, are sensitive to weather conditions, and the health of the grass suffers if fields are overused or improperly cared for (Cheng et al. 2014). Alternatively, opponents of artificial turf are concerned about exposure to hazardous chemicals such as polycyclic aromatic hydrocarbons (PAHs), phthalates, per- and polyfluoroalkyl substances (PFAS), and metals leaching from the synthetic materials, as well as the problematic environmental profile that can exacerbate local climate events (TURI 2019). In addition, artificial turf cannot be recycled and thus is consigned to a landfill after its useful life of 8-15 years, making it unsuitable for a circular economy.

Despite its increasing market share, the installation of artificial turf in communities around the US is highly controversial, in large part due to the sparce and mixed evidence for its safety. Importantly, the financial incentives of manufacturers to promote adoption of their products make this a prime target for manufactured doubt and scientific

obfuscation (Goldberg and Vandenberg 2021). To date, the majority of scientific studies on artificial turf have focused on chemical components and leachates, identifying numerous carcinogens, neurotoxicants, and endocrine disrupting chemicals, many of which may have non-monotonic dose response curves that indicate there may be no safe level of exposure (Zoeller and Vandenberg 2015; Hill et al. 2018; Gomes et al. 2021). A few studies have attempted to estimate human exposure from inhalation and ingestion using surrogate biological fluids, environmental monitoring, and calculated estimates, generally finding low biological uptake and estimating low risk (Schilirò et al. 2013; Cheng et al. 2014; Peterson et al. 2018; Donald et al. 2019; Perkins et al. 2019; Pronk et al. 2020). Human epidemiology and laboratory toxicity studies are necessary bridge the gap between the established presence and release of hazardous chemicals by artificial turf and the current exposure estimates.

The purpose of this review is to examine research regarding the possible health effects from exposure to artificial turf and its components, both direct (athletics) and indirect (environmental contamination). Studies were identified from peer-reviewed literature and government-sponsored sources using Google Scholar and PubMed. Non-peer reviewed studies with a financial conflict of interest were excluded. We discuss ecotoxicology studies using invertebrate models, vertebrate animal studies, and human epidemiology studies of associations between artificial turf usage and disease. In addition, we discuss the areas where research is lacking and provide recommendations for future studies that will aid in decision making on artificial turf in communities.

Composition and Identified Chemicals

Artificial turf is made of several synthetic layers on top of natural soil (Figure 1). From the soil to the surface, there is typically a stone foundation layer made of compacted crushed concrete or granite, a plastic shock-absorbing layer to soften the ground, a synthetic fabric layer to prevent weeds, a plastic carpet layer to hold the artificial grass in place, a rubber infill layer to keep the artificial grass upright, and a layer of plastic grass fibers. These layers may be composed of nylon, polypropylene, polyethylene, polyurethane, synthetic rubber, and other polymers, including proprietary compositions. The most cost-effective infill is crumb rubber made from virgin rubber or shredded recycled tires; less common alternatives include thermoplastic elastomers, waste athletic shoes, acrylic coated sand, coconut fibers, cork, and sand (Massey et al. 2020).

Most analyses of the health and environmental hazards of artificial turf usage have focused on crumb rubber, although each synthetic layer can provide additional sources of exposure to hazardous chemicals. Crumb rubber is typically made from end-of-life automobile tires. It has been marketed as sustainable due to its status as a recycled material and alternative to the typical methods of tire disposal, burning or illegal dumping (Gomes et al. 2021). A single professional-size sports field requires crumb rubber from 20 – 40,000 tires at initial installation, with additional crumb rubber granules required for replenishment during the lifetime of the field as the granules migrate during use (Watterson 2017; Brandsma et al. 2019). In the US alone, tens of millions of tires have been used in artificial turf fields and to cover playground surfaces (Watterson 2017).

The widespread use of crumb rubber in the environment is particularly troublesome because of the large number of chemicals that have been identified in tires and rubber leachate. Tire rubber, which is composed of natural and synthetic rubber polymers, reinforcing agents, aromatic extender oils, vulcanization additives, antioxidants, and processing aids, has been widely shown to contain hazardous chemicals, most notably volatile and semi-volatile organic compounds, PAHs, heavy metals, phthalates, vulcanization agents, and antioxidants (Gomes et al. 2021; Armada et al. 2022). For example, an environmental transformation product of the rubber antioxidant N-(1,3-dimethylbutyl)-N′-phenyl-p-phenylenediamine (6PPD) has been shown to cause acute low dose toxicity in juvenile coho salmon exposed through road runoff (McIntyre et al. 2021; Tian et al. 2021; Tian et al. 2022). As a ubiquitous tire chemical, 6PPD most likely leaches from crumb rubber in artificial turf fields and undergoes transformation into the extremely ecotoxic 6PPD-quinone in the local environment.

Recent chemical analyses of crumb rubber and other artificial turf components have identified hundreds of chemicals, including known carcinogens, neurotoxicants, and endocrine disrupting chemicals (Table 1) (Massey et al. 2020). Notably, recent studies of whole artificial turf and non-crumb rubber components have identified PFAS as an emerging class of contaminants to be considered alongside known rubber chemicals, emphasizing that although crumb rubber is notoriously hazardous, other components of turf should be studied as well (Naim 2020). Another recently recognized health hazard of artificial turf is the introduction of micro and nanoplastics into the environment, an emerging environmental concern (Wright and Kelly 2017). Infill, whether crumb rubber or other polymeric materials, is a loose component with a diameter of < 5 mm, meeting the definition of microplastics (Armada et al. 2022). Infill can wash off fields into the environment, collect in players' clothes, or be accidentally ingested during athletics or by babies and toddlers, resulting in additional sources of exposure (Lopez-Galvez et al. 2022).

Invertebrate Studies on the Health Impacts of Artificial Turf

The potential toxicity of artificial turf components has been studied most extensively from the perspective of ecotoxicology, focusing on organisms whose habitats are directly impacted by artificial turf installation. These studies have investigated only crumb rubber, which is also widely used in playgrounds and landscaping.

To model exposure to newly installed artificial turf fields, earthworms were housed in a tank containing a mixture of virgin crumb rubber and compost for 34 days. Exposed worms had reduced growth trajectory compared to earthworms living in only compost, but had the same mortality rate and susceptibility to light and stress (Pochron et al. 2017). To model exposure to fields containing aged crumb rubber, a follow-up study housed earthworms in a mixture of 7-year-old crumb rubber and compost. Exposed worms had significantly increased susceptibility to light and stress compared to earthworms living in only compost, but had the same mortality rate and growth trajectory (Pochron et al. 2018). Overall, the authors concluded that both new and aged crumb rubber pose risks to earthworms.

In another study of crumb rubber ecotoxicity, neonate *Daphnia magna* were cultured in aqueous extracts of newly shredded crumb rubber made from waste tires, crumb rubber cut from new tire tread, 6-year-old crumb rubber from a campus walkway, and 6-year-old crumb rubber from a playground (Lu et al. 2021). In addition, the samples of crumb rubber from new tire tread were irradiated with UV light to mimic outdoor aging. The *D. magna* exposed to the leachate of newly shredded crumb rubber had 100% mortality after 24 hours of exposure, whereas the *D. magna* exposed to new tire tread had significantly more deaths than the untreated control. The aged samples did not have increased mortality compared to the control. Exposure to new tire tread treated with UV light significantly increased mortality with increasing duration of UV treatment, indicating that newly installed crumb rubber has the highest toxicity risk. New tire particle leachate has also been shown to disrupt oyster development more than rubber leachate from aged tires (Tallec et al. 2022). Similar to the *D. magna* study, a study of mortality of zooplankton following exposure to seawater crumb rubber leachate revealed a dose-response relationship with increasing mortality with increasing leachate concentration (Halsband et al. 2020). In both studies, the only endpoint assessed was mortality, so non-lethal toxic effects from aged crumb rubber and low concentration leachates cannot be ruled out. Conversely, a study of the insect *chironomus riparius* and the worm *lumbriculus variegatus* in freshwater sediment contaminated with crumb rubber of various particle sizes did not identify any impact on growth, emergence, or reproduction (Carrasco-Navarro et al. 2022).

In Vitro and Vertebrate Animal Studies on the Health Impacts of Artificial Turf

Exposure of fish models to crumb rubber has identified potential ecotoxicity from leachate and granules that wash off fields and into the environment. Mummichogs and fathead minnows exposed to crumb rubber granules in artificial seawater environments ingested the granules, resulting in PAH adsorption into the bile and increase liver enzyme activity (LaPlaca and van den Hurk 2020). In addition, zebrafish embryos exposed to tire particle leachate developed malformations, whereas embryos exposed to nano-size tire particles had increased mortality and hatching delay (Cunningham et al. 2022).

Only one peer-reviewed study has used *in vitro* models or vertebrate animals as translational models for investigating the health impacts of artificial turf exposure on humans. This study assessed the reproductive toxicity of aqueous leachate from new crumb rubber in fertilized chicken eggs (Xu et al. 2019). Embryonic day 0 eggs were exposed by coating, dipping, or microinjecting and embryos were extracted at E3 or E7 for analysis. No significant morphological abnormalities were observed from dipping or coating. Eggs with leachate injected into the yolk had reduced growth, severe developmental changes, and impaired brain and cardiovascular system development. All the treatments showed signs of the disruption of thyroid hormone signaling, suggesting an endocrine mechanism of action (Xu et al. 2019).

The National Toxicology Program (NTP) has performed the only other human translational studies of crumb rubber, using rodents and *in vitro* models, which are published in two

reports (National Toxicology Program 2019; Program 2019). In the rodent studies, adult female mice were exposed to new crumb rubber granules by oral gavage, dosed feed, or bedding for 14 days. Mice in the dosed feed group actively avoided consuming crumb rubber particles, but had statistically significantly lower ovary and thymus weights and altered hematology values at the end of the study. Mice in the crumb rubber bedding treatment group had statistically significantly increased liver weight. Overall, the authors of the study concluded that none of the changes were biologically relevant and that leachability of chemicals in crumb rubber is low in biological fluids. This is consistent with studies using simulated biological fluids (Pronk et al. 2020). NTP's epithelial cytoxicity studies exposed skin (HaCaT), lung (HPL-1D), and small intestine (FHs-74-Int) cells to culture media pre-incubated with crumb rubber granules and found that the pre-conditioned media was cytotoxic to all cell types. However, when crumb rubber was pre-incubated in artificial lung fluid and used for lung cell culture, toxicity was reduced, suggesting that cell culture media may not be an appropriate model for biofluids. In both of the NTP studies, the routes of exposure modeled were direct dermal and oral exposure to crumb rubber. These studies did not consider other routes of exposure, including from runoff, or other components of artificial turf.

Human Studies on the Health Impacts of Artificial Turf

In 2014, a professional soccer coach released anecdotal evidence to suggest that artificial turf exposure could be causing cancer in soccer players, particularly goalies, causing a media frenzy on artificial turf and cancer risk (Bleyer 2017). Although multiple athletes and coaches have blamed crumb rubber on incidents of cancer, the human epidemiology evidence for an association is scant and preliminary. In response to the soccer coach's claims, an investigation of incidences of cancer among skilled female college soccer players in Washington compared to other residents of the state found no significant association (Washington State Department of Health 2017). However, this study was limited to a single university and did not include most female soccer players in the state. An investigation of the association between turf field density and incidences of cancer in counties in California also found no significant association (Bleyer and Keegan 2018). A 2022 simulation of cancer risk in children due to PAH exposure from rubber playground surfaces estimated a ten times higher risk compared to soil surfaces (Tarafdar et al. 2020). No human epidemiology studies on artificial turf or crumb rubber have investigated any endpoints other than cancer.

Future Directions

More Research is Needed

As this review reveals, few studies have investigated the potential health effects of artificial turf exposure using actual samples of artificial turf or its components. All of the studies reported above used crumb rubber, a popular infill material. Crumb rubber is considered to be one of the riskiest components of artificial turf as it is known to contain high levels of PAHs and metals. However, artificial turf contains many additional components that may leach harmful chemicals. Of note, artificial glass fibers have been shown to leach multiple

phthalates, which are known reproductive toxicants, and various PFAS have been identified in artificial turf samples (Glüge et al. 2020; Naim 2020; Gomes et al. 2021). Additional studies that incorporate all components of artificial turf are strongly needed.

With the exception of ecotoxicology, the studies discussed in this review have focused on athletic exposure to artificial turf. Children and adults utilize turf fields for recreational purposes with regularity and for long periods of time, resulting in acute and chronic inhalation, dermal, and oral exposures. Although some of these exposure routes have been modeled, future studies should consider all routes of exposure various exposure durations. In addition, epidemiology studies have only investigated cancer in athletes and have been limited in scope. Additional studies are strongly needed to consider associations in young children and other sensitive populations, developmental and reproductive endpoints, and community exposures. Laboratory studies should also consider community exposures through runoff and water and soil contamination. Multiple studies have collected rainwater from turf pitches for measuring chemical leachate from artificial turf, indicating that contaminated runoff is highly likely (Gomes et al. 2021). In addition, the partitioning relationship of organic leachate or emissions from artificial turf into local air, soil, and water has not been studied (Donald et al. 2019).

Research Challenges

The paucity of health and toxicity studies on artificial turf stands in stark contrast to the large body of literature that has identified chemicals in crumb rubber and other artificial turf components and leachate. A major research challenge for future studies is bridging this gap to incorporate knowledge of chemical components to expand toxicity studies beyond crumb rubber. To be most representative, studies should extract exposure samples from artificial turf pieces, both virgin and from existing fields, and collect runoff from fields, for use in *in vitro* and *in vivo* studies, especially in vertebrate models. Chemical mixtures determined from extraction studies and representing leachate may also be useful for determining the most active toxicants and identifying synergistic mixture effects. There is also a wide range of brands and manufacturers of artificial turf, each with their own structure and layers that may include proprietary materials. Studies should incorporate samples from major companies in all markets around the world.

Implications for Risk Assessment

Due to the controversy over artificial turf usage in communities, regulatory agencies at local, state, and national levels have relied heavily on the scant available data. In addition, the NTP, Environmental Protection Agency (EPA), and some state governments have commissioned and performed their own studies. The relevant studies with publicly available data are discussed above. In addition, the EPA has ongoing studies to collect information for risk assessment on synthetic turf playing fields, although only on crumb rubber (Environmental Protection Agency 2019). Due to the paucity of health-focused studies on artificial turf, risk assessors have not been able to make confident recommendations and communities have come to a wide range of conclusions about installation of artificial turf in parks and schools.

Conclusions

In conclusion, few laboratory and epidemiology studies have been performed on the potential health impacts of artificial turf in athletes and communities, despite the abundance of evidence of carcinogens, neurotoxicants, mutagens, and endocrine disruptors in its components. The existing studies have focused exclusively on a single component, crumb rubber infill, neglecting the complexity of the mixture caused by simultaneous exposure to all components. Peer-reviewed studies using I systems, translational animal models, and ecotoxicology models would greatly benefit both risk assessment and consumers as the installation of artificial turf fields is a controversial and ongoing issue in communities and school districts.

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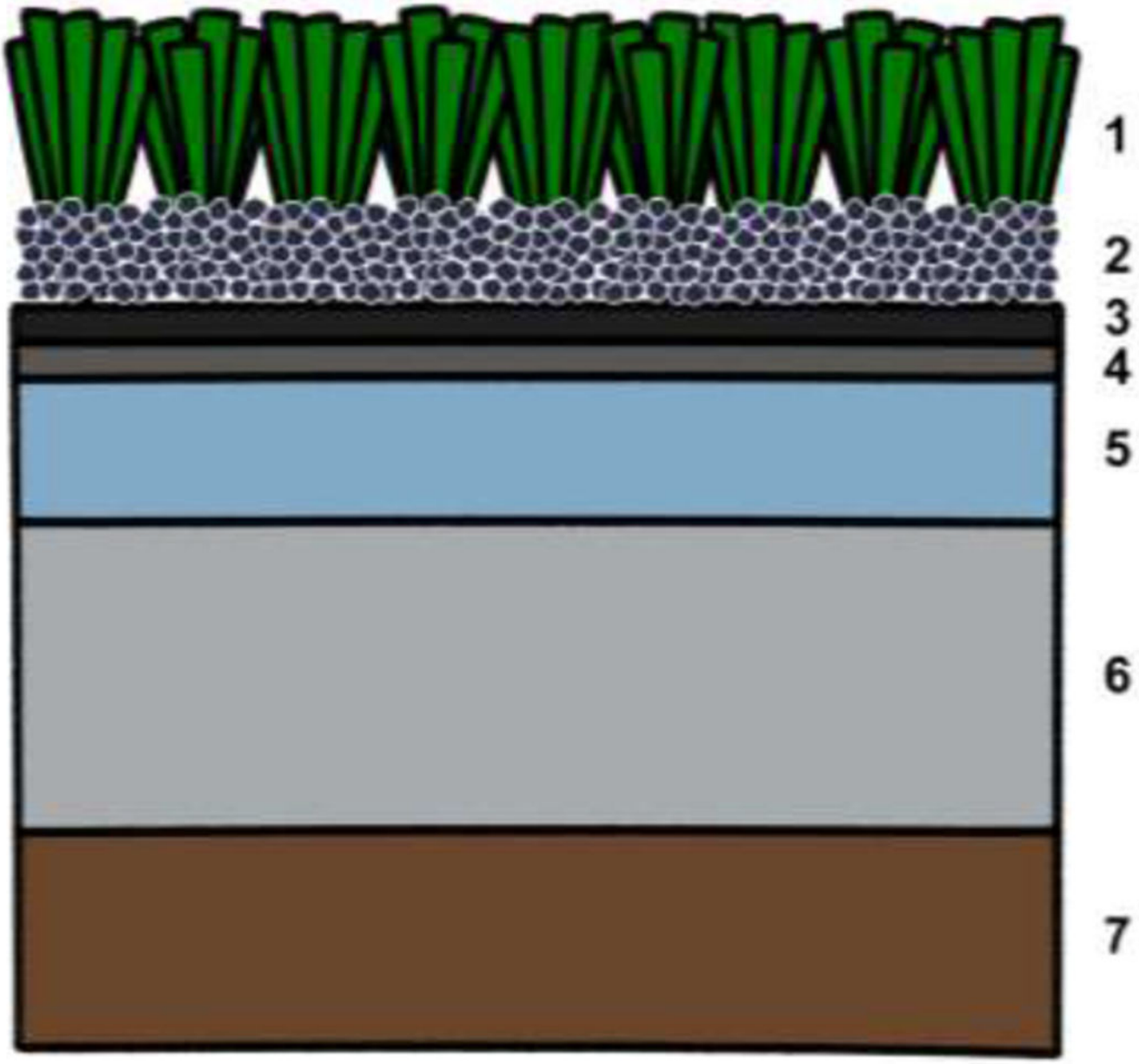

Figure 1: General structure of artificial turf layers.

On the surface, plastic fibers (1) are surrounded by infill, usually crumb rubber (2), at the base. These rest on top of additional layers of synthetic, engineered, and natural materials which may include a plastic carpet (3), an anti-weed barrier (4), a shock absorbing pad (5), crushed concrete (6), and finally natural soil (7).

Table 1:

Chemicals Identified in or Released from Artificial Turf and Its Components*

Class	Individual Chemicals	Class	Individual Chemicals
Polycyclic aromatic hydrocarbons (PAHs)	naphthalene acenaphtalene acenaphthene fluorene phenanthrene anthracene fluoranthene pyrene benzo[a]anthracene chrysene benzo[b]fluoranthene benzo[k]fluoranthene benzo [a]pyrene indeno[1,2,3-cd]perylene dibenzo[a,h]anthracene benzo[g,h,i]perylene	Polychlorinated biphenyls (PCBs)	PCB18 PCB28 PCB31 PCB33 PCB49 PCB52 PCB66 PCB70 PCB74 PCB91 PCB95 PCB99 PCB101 PCB110 PCB118 PCB128 PCB138 PCB141 PCB146 PCB149 PCB151 PCB153 PCB170 PCB174 PCB177 PCB180 PCB183 PCB187
Volatile organic compounds (VOCs)	toluene ethylbenzene propylbenzene iso-propylbenzene m-butylbenzene xylenes p-isopropyltoluene 1,2,4-trimethylbenzene 1,3,5-trimethylbenzene trichloromethane cis-1,2-dichlorthene benzene methyl isobutyl ketone 4-methyl-2-pentanone acetone chloroform chloromethanie methylene chloride carbon tetrachloride aniline cyclohexane methane		
Plasticizers and other semi-volatile organic compounds	benzyl butyl phthalate dibutyl phthalate di(2-ethylhexyl)phthalate diisononyl phthalate dimethyl phthalate diethyl phthalate dicycylohexyl phthalate di(2-ethylhexyl) adipate diisobutyl phthalate dinonyl phthalate dipheylphthalate bisphenol A	Rubber additives and antioxidants	4-t-octylphenol iso-nonylphenol 4-n-nonylphenol benzothiazole 2-hydroxybenzothiazole 2-mercaptobenzothiazole 2-methoxylbenzothiazole 2-aminobenzothiazole n-cyclohexyl-1,3-amine butylhydroxytoluene 4-tert-butylpyridine butylated hydroxyanisole 2-propyl-methyl pentanoic acid methyl 2alpha-D-xylofuranoside 2-ethyltetra-hydrothiopene 4-methyl-4-heptanol 2-butyl tetrathydrothiopene N-N-diethyl-3-methyl benzamide 2-2-7 trimethyl-3-octyne

Class	Individual Chemicals	Class	Individual Chemicals
PFAS	general PFAS content(Naim 2020) perfluorooctanoic acid(Naim 2020) perfluorooctane sulfonate(Naim 2020)	Metals	zinc calcium magnesium aluminum iron barium cobalt copper manganese lead strontium arsenic cadmium mercury nickel chromium berellium lithium selenium barium molybdenum titanium

* Chemicals from the comprehensive review by Gomes (Gomes et al. 2021) unless otherwise cited. Not an exhaustive list of all chemicals measured in artificial turf and crumb rubber.

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Tests of rubber granules used as artificial turf for football fields in terms of toxicity to human health and the environment

Beata Grynkiewicz-Bylina[1], Bożena Rakwic[1] & Barbara Słomka-Słupik[2]✉

Rubber waste, in the form of granules of styrene butadiene rubber and ethylene-propylene-diene-monomer with a particle size of 0.5 to 4 mm, is broadly used for the construction of synthetic surfaces of sport fields. This method of recycling may be significantly limited due to the restrictions on polycyclic aromatic hydrocarbons (PAHs) content in rubber granules in the European Union since 2022. This also applies to the recommendations of the European Chemicals Agency in relation to the identification of other hazardous chemicals in this waste, including metal elements. The scope of the research included the identification of organotin compounds, PAHs content and 18 elements leached from recycled rubber granules in terms of substances harmful to human health and to natural environment. The research covered 84 samples of rubber granules collected from the surface of football pitches or supplied by recyclers in Poland. The test results showed an over-standard content of PAHs in rubber granules. This result confirms the need to develop alternative directions of rubber granules application: construction and hydro construction, reinforcing soil and roadsides, asphalt pavements, making retaining walls, anti-shock and anti-vibration slabs, soundproofing and damping screens, paving stones and landscaping elements.

Polymer waste, due to the increasing amount and long decomposition time, belongs to the group of wastes that are particularly problematic for the natural environment. Among them are recycling end-of-life car tires (ELTs) in a significant quantity. More than 3.1 million tons of tires are used annually in the EU, according to the European Tyre & Rubber Manufacturers Association[1]. According to: Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste[2], Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles[3], "European Green Deal"[4] and "The New EU Action Plan for the Circular Economy for a Cleaner and More Competitive Europe"[5], activities should be taken to increase the use of secondary raw materials obtained from car tires. Material recycling carried out with the use of physical processes including cleaning, multi-stage mechanical grinding, screening of rubber material, separation of metal and textile parts is used[6–10]. After these processes, fragmented rubber materials: steel wires and textile cord are obtained. Depending on the degree of grinding, the rubber material can be used in various ways[11–16]. According to data from 2018, more than 1.5 million tons of car tires were processed in this way. This accounts for 83% of recycled tires[1]. Popular is the construction of sport fields with artificial turf made of rubber granules made from tires with a particle size of 0.5 to 4 mm[17]. Granules are a filling material ensuring the resilience of the surface and absorbs falls[18]. If the appropriate binder is selected, granules are used to make solid boards for the surface of sport fields and playgrounds. Apart from ELTs, other types of polymers from household appliances and the automotive industry are used in the construction of sport fields, but their amount did not exceed 2% of the granules used for the surface of sport fields, in exemplary 2015 year[17]. They were ethylene-propylene-diene monomer (EPDM) and thermoplastic elastomers: styrenic block copolymers (TPS), thermoplastic polyolefins (TPO), thermoplastic vulcanizates (TPV), thermoplastic polyurethanes (TPU), thermoplastic copolyester (TPC) and thermoplastic polyamides (TPA)[17,19]. The chemical composition of tires does not differ from the chemical composition of rubber granules obtained in the recycling process. The car tires granules contain 43% of SBR (styrene-butadiene rubber), 28% of carbon black, 2% of zinc oxide, 1% of sulphur and 6 to 8% of additives containing organic low-molecular substances (OLMS)[17]. OLMS are extender oils, vulcanization accelerators (mainly amine, thiuram and carbamate

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derivatives), antioxidants (most often phenolic derivatives), organic peroxides and others[17]. Literature data shows that in addition to the above-mentioned ingredients there may be chemicals that are toxic to human health and to environment in recycled tire granules used in the sport fields and playgrounds[18,20–32]. Their source may be raw materials of inadequate quality or impurities from the rubber vulcanization process[18,33]. These substances include polycyclic aromatic hydrocarbons (PAHs), heavy metals: lead (Pb), cadmium (Cd), arsenic (As) and mercury (Hg); phthalates and volatile organic compounds (VOCs). PAHs are classified according to the Regulation of the European Parliament and of the European Council No. 1272/2008[34] as carcinogenic substances of category 1B. Benzo[*a*]pyrene belongs to mutagenic substances of category 1B and toxic to reproduction in category 1B, as well. Chrysene belongs to mutagenic substances of category 2. Pb, Cd, Ni and Hg are also carcinogenic or may be toxic to reproduction. These heavy metals accumulate in human organisms and negatively affect their organs and systems, including the nervous and hematopoietic[31,35,36]. Diisobutyl phthalate (DIBP), dibutyl phthalate (DBP), benzyl butyl phthalate (BBP) and bis(2-ethylhexyl) phthalate (DEHP) are classified as harmful to reproduction category 1B according to the EC Regulation No 1272/2008[34]. Additionally, BBP and DBP phthalates are classified as hazardous to the aquatic environment, according to the EC Regulation No 1272/2008[34]. Dangerous chemicals can get into the human body through the alimentary and inhalation route and through direct contact with the skin[17,25,37,38]. The routes of exposure are related to the nature of the activities performed, i.e. running on the pitch, jumping, slips and falls. These substances can also get into the soil and groundwater[39]. Another problem is that the rubber granules with a particle size of less than 5 mm are classified as a microplastic[40]. This kind of microplastic is removed from sport fields by users or washed away by rainwater. In consequence, it occurs in groundwater and in water flowing out of wastewater treatment plants. After entering the environment, microplastic does not biodegrade but accumulates in the living organisms, including fish and crustaceans, consumed by humans. The release of microplastics contributes to the contamination of ecosystems and food chains. Exposure to microplastics is associated with negative (eco)toxic and physical effects on living organisms. In order to limit the above-mentioned environmental hazards, the work has started on adopting regulations on microplastics, in the European Union since 2016. ECHA's Risk Assessment Committee (RAC), in June 2020, recommended a ban on microplastics as a filler material in artificial turf pitches after a 6-year transition period[40]. Since 2020 European Commission has been working on developing a proposal to amend the list of substances that are restricted by Annex XVII to the REACH Regulation[41]. In addition, this regulation provides a list of permitted concentrations of PAHs and phthalates. The Supplementary Information includes a detailed description of the European guidelines of the permissible concentrations of chemical substances in materials. Supplementary Tables S1 and S2 present the molecular structures of all of the discussed substances.

The EU requirements for PAHs content in rubber granules used in sport fields will affect the need to increase the quality control of granules in the scope of hazardous substances. If it turns out that the admissible new limits are not complied with, it will be necessary to intensify the search for alternative directions of their application.

The article presents the results of a research work aimed at assessing SBR and EPDM rubber granules from recycling, intended for the construction of sport field surfaces in terms of substances harmful to human health, taking into account their impact on the natural environment. The research was carried out for 17 granules from the surface of sport fields and 67 granules were supplied by recyclers. The scope of the work included the identification of PAH content in rubber granules. From selected specimens leached 18 elements and organotin compounds, as important parameters in assessing the impact on the health of sport fields users, with a broader spectrum than the content of Pb and Cd limited by the requirements of the REACH Regulation.

The PAHs content obtained from the tests was assessed in the light of the requirements of the above-mentioned regulation applicable to rubber granules intended for the construction of sport fields.

The characteristics of the impact of granules on the environment were based on the study of the leachability of PAHs, Pb, Cd, total chromium (Cr) and hexavalent (Cr (VI)), Hg, zinc (Zn) and tin (Sn). In order to achieve the above-mentioned goal, rubber granules used in the construction of sport fields, in which the presence of PAHs was identified through tests, were selected.

Materials and methods

Description of test samples and theirs preparation. 84 samples of recycled rubber granules with a particle size of 0.5 to 4 mm, produced for the construction of sport field surfaces, were tested. The samples of rubber granules were collected from 17 sport fields and 67 samples rubber granules were supplied by recyclers. Research included 57 samples of SBR granules and 27 samples of EPDM granules. The numbers of samples in relation to their sources of origin are shown in Fig. 1.

The samples were taken from the surface of sport fields with artificial turf in accordance with the laboratory instructions or delivered to the laboratory by recyclers. The mass of the granulate samples delivered for testing was approx. 0.5 kg. Sampling from sport fields was carried out using a scheme based on 6 sampling points, shown in Fig. 2, in accordance with point 4 of the FIFA guidelines: "Quality Programme for Football Turf. Handbook of Test Methods for Football Turf". The number and weight of granular samples and the locations of the granular sampling points on the field indicated in the aforementioned guidelines are indicated in order to obtain a representative homogenized granular sample for the tested field[42].

At the designated points (1 ÷ 6), 6 samples of granulate were collected. The collected and secured samples were stabilized in the laboratory conditions of natural drying, in which the moisture of the sample was in equilibrium with the ambient moisture. After stabilization, the samples were purified and homogenized to give a pooled sample. Images of exemplary SBR and EPDM granules used in the study are shown in Fig. 3. The average values of the physical parameters of the tested rubber granules are given in Table 1.

Samples weighing at least 100 g were taken from the granulate samples using the quartering method. This way allowed to ensure full qualitative and quantitative compliance of the sample composition with the composition

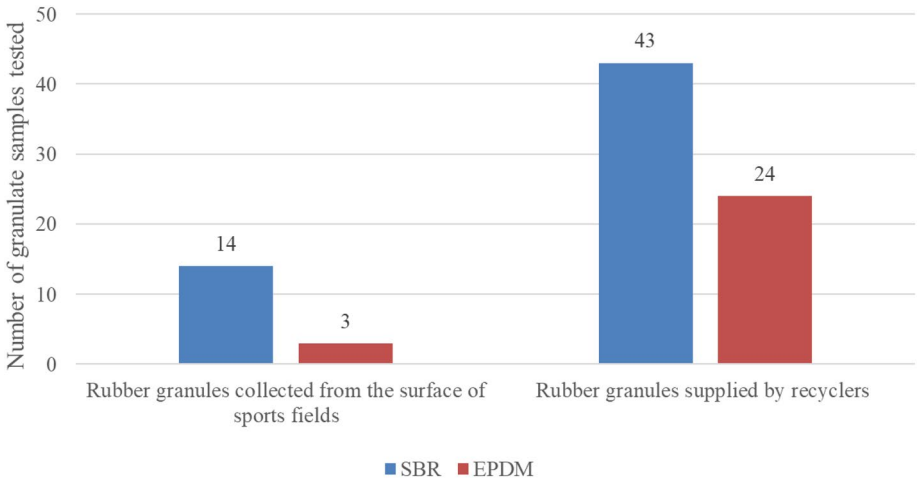

Figure 1. Number of samples of the tested SBR and EPDM granules in relation to their sources of origin.

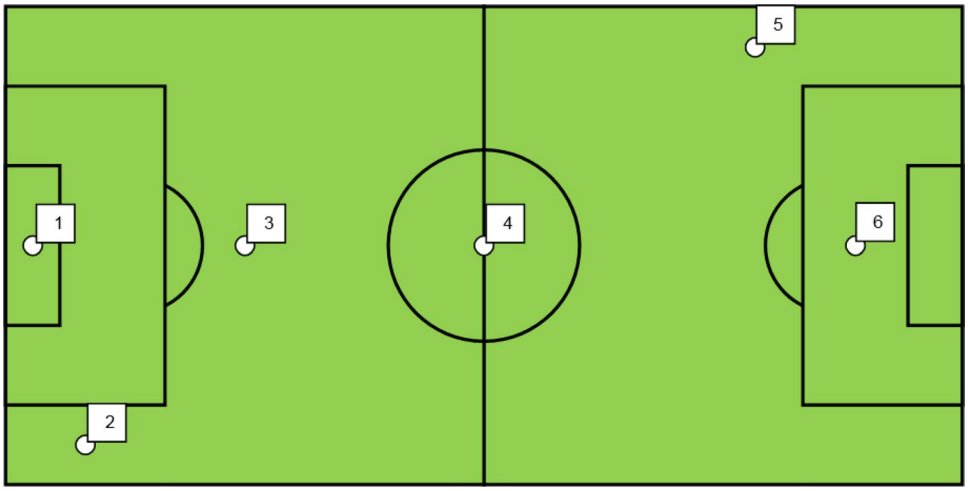

Figure 2. Scheme of distribution of granulate sampling points on a sport field. Designation: 1 location and numbers of granulate sampling points.

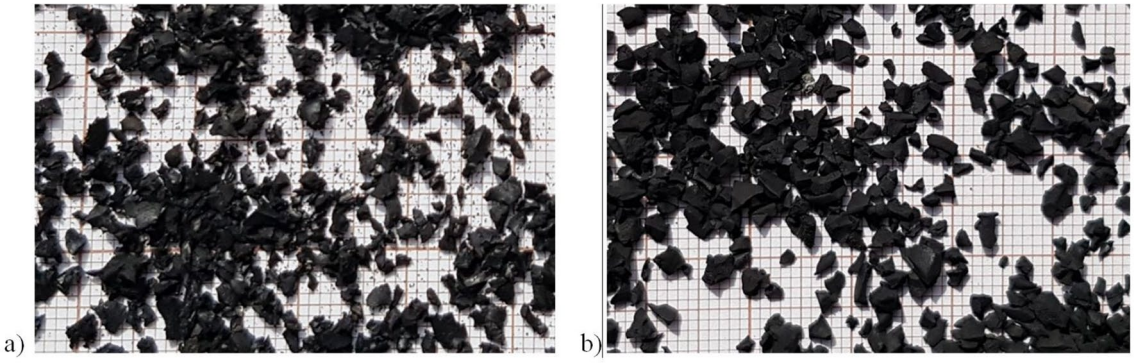

Figure 3. Samples taken from sport fields: (**a**) SBR granules, (**b**) EPDM granules.

of the analyzed material. Samples for testing the content of PAHs were grounded by grinding in a cryogenic mill 6770 Freezer/Mill, by SPEX SamplePrep LLC. Samples for testing other substances were not crushed.

The scope and methods of testing rubber granules. The scope of the research on rubber granules included: content determination of the PAHs, leached elements, organotin compounds and PAHs. In all sam-

Properties	SBR granules	EPDM granules	Test methods
Specific gravity	1.160 kg/m^3	–	ASTM D1817-05
Bulk density	405 kg/m^3	500 kg/m^3	EN 1097-3 or EN ISO 60
Particle size range	0.8–2.0 mm	0.5–2.5 mm	ISO 1322-2 or ISO 2591-1
Particle size < 0.5 mm	0.15%	1.0%	DIN 53477 or ISO 2591-1
Total polymer content (RCH)	45%	–	ISO 9924-3
Ash content	8%	–	ISO 9924-3
Moisture content (Loss: 2 h, 105 °C)	< 1%	–	ASTM D1509
Free metal content	< 0.002%	–	ASTM D5603
Free fibre content	< 0.001%	–	ASTM D5603
Other contamination	< 0.002%	–	ASTM D5603

Table 1. Some physical parameters of the tested SBR and EPDM granules (data from the Technical Data Sheets provided by the recyclers).

ples of rubber granules, the content of 8 polycyclic aromatic hydrocarbons, resulting from the REACH Regulation, was determined: benzo[*a*]pyrene (BaP), dibenz[*a,h*]anthracene (DBAhA), benzo[*e*]pyrene (BeP), benz[*a*]anthracene (BaA), chrysene (CHR), benzo[*b*]fluoranthene (BbFA), benzo[*j*]fluoranthene (BjFA) and benzo[*k*]fluoranthene (BkFA). The content of indeno[1,2,3-*cd*]pyrene (IcdP), benzo[*ghi*]perylene (BghiP), phenanthrene, anthracene, fluoranthene, pyrene and naphthalene was determined for 38 samples from recyclers, additionally, that the number of PAHs covered by the requirements of the document[43] was increased by 7.

The leaching tests of elements and organotin compounds were carried out for 18 samples and the leachability of PAHs and elements were carried out for 4 samples. The tests were carried out with the methods listed below, using the following apparatus.

The content and leachability of PAHs from rubber granules was determined by gas chromatography with tandem mass spectrometry (GC–MS/MS) using a gas chromatograph coupled with a mass detector GCMS/MS/7890B/7000C. The method was chosen because of the high sensitivity and selectivity obtained for low PAHs levels when used GC–MS/MS, compared to other commonly used analytical techniques such as high-performance liquid chromatography (HPLC) combined with UV, fluorescence or diode array detector (DAD). In studies carried out with the use of the above-mentioned techniques trace amount of PAHs identification is easily interfered by sample matrix and other components if only based on retention[44].

Determination of leaching of elements: Al, Sb, As, Ba, B, Cd, Co, Cu, Pb, Mn, Hg, Cr, Ni, Se, Sr, Sn, Zn and elution of the Cd, total Cr, Pb, Sn, Zn from rubber granules was carried out by the inductively coupled plasma mass spectrometry (ICP-MS) method with the use of Agilent 7900 ICP-MS (Agilent Technology, Santa Clara, CA, USA). The selected method is characterized by a low limit of quantification, which stands out among other instrumental methods used in elemental analysis, such as ICP-OES or AAS (Inductively coupled plasma–optical emission spectrometry or atomic absorption spectrometry). It is also characterized by high sensitivity and precision, selectivity enabling the simultaneous determination of many elements in complex matrices in a wide range of concentrations.

Leachability of Cr (III) and Cr (VI) and elution of Cr (VI) from rubber granules were determined by high-performance liquid chromatography with inductively coupled plasma mass spectrometry (HPLC-ICP-MS) using Agilent 7700 Series ICP-MS with Agilent 1260 Infinity series HPLC (Agilent Technology, Santa Clara, CA, USA). The decision to use HPLC in conjunction with ICP-MS was dictated by the need to determine chromium in two oxidation states. In the case of the selected method, the speciation separation of Cr (III) and Cr (VI) takes place on the HPLC column, where Cr (III) and Cr (VI) are adsorbed. In the next step it allows for the separation and determination of Cr (III) and Cr (VI) in the ICP-MS spectrometer. The HPLC-ICP-MS method is characterized by a short analysis time and a low detection limit compared to the other spectrophotometric methods used for determination of Cr (VI). The leaching of organotin compounds was assessed on the basis of the results of total Sn leaching.

Cold-vapor atomic absorption spectroscopy (CV-AAS) with the PerkinElmer FIMS 100 mercury analyser was selected for the Hg leaching study due to the use of a unique technique of mercury vapour measurement at room temperature. Among other alternative methods of Hg determination in aqueous solutions (ICP-MS or GF-AAS (graphite furnace atomic absorption spectrometry)), the selected method is distinguished by a low limit of quantification, simple preparation of samples for analysis, easy elimination of interference and short analysis time.

Tests of the content of PAHs. Shredded samples of rubber granules were subjected to the ultrasonic extraction process for 1 h with the use of toluene as a solvent. Samples were taken from the obtained extract for chromatographic analysis. The analysis was carried out for the following conditions: dispenser operation mode: splitless, carrier gas: Helium: 1.8 ml/min, DB-EUPAH column with dimensions: 20 m × 180 µm × 0.14 µm (the 20 m column is in the form of a coiled wire), injection temperature: 275 °C. The PAHs were identified on the basis of mass spectra and retention times—Table 2.

Tests of the leaching of elements and organotin compounds. Samples of rubber granules for the study of the leaching of organotin elements and compounds were extracted in a solution of hydrochloric acid

Compound	Target ion	Identifying ions
BaP	252	250; 126
DBAhA	278	279; 139
BeP	252	250; 125
CHR	228	226; 113
BbFA	252	250; 126
BaA	228	226; 114
BjFA	252	250; 125
BkFA	252	250; 126
IcdP	276	277; 138
BghiP	276	277; 138
Phenanthrene	178	176; 152
Anthracene	178	176; 152
Fluoranthene	202	200; 101
PYR	202	200; 101
Naphthalene	128	127; 128

Table 2. Target and identification ions and retention times for the determined PAHs.

(HCl), with concentration 0.07 ± 0.005 mol/dm^3 in temperature 37 ± 2 °C. Solutions for the determination the Cr(VI) and Cr(III) prepared by diluting the extraction solution to obtain the pH equal to 7.0 ± 0.5 by adding 1 ml of 0.07 mol/dm^3 ammonia and 60 µL of 0.1 mol/dm^3 EDTA solution. In parallel, a reagent blank was prepared, as the test samples were. The obtained extracts were analyzed by ICP-MS and HPLC-ICP-MS. The analyzes were performed for the isotopes of the elements: Al—27, Sb—121, As—75, Ba—137, B—11, Cd—111, 112, Cr—52, 53, Co—59, Cu—63, Pb—206, 207, 208, Mn—55, Hg—201, Ni—60, Se—78, Sr—88, Sn—118, 120, Zn—64, 66.

Tests of the leachability of polycyclic aromatic hydrocarbons (PAHs) and elements. Determination of the dry mass of the rubber granulate samples for the leachability tests was carried out in accordance with ISO 11465:1999[45], using a drying oven (Pol-Eco-Apparatus SLW-115 Top, Wodzisław Śląski, Poland) and analytical balances (SARTORIUS, Kostrzyn Wlkp. i Radwag, Radom, Poland).

The rubber granulate samples were dynamically washed with deionized water according to EN 12457-4:2002[46] providing a ratio of 1 ml of liquid to 1 g of rubber granulate. The pH value of the water used for dynamic leaching did not exceed 6.7. Elution was performed using a bottle/tube roller mixer (Thermo scientific model, Thermo Fisher Scientific (China) Co., Ltd., Shanghai China). After washing, the effluents were left for 15 min and then filtered through 0.45 mm membrane filters using a pressure filtration device.

The leachate obtained from dynamic leaching was subjected to the process of transferring PAHs from the water phase to the organic phase using the algorithm:

- SPE column: C18 bed—6 ml/1000 mg;
- activation: 10 ml of methanol, 10 ml of methanol:water (40:60) (v:v), flow: 1 ml/min;
- sample:eluting solution of methanol (100 ml:10 ml), flow: 0.5 ml/min;
- drying: minimum 15 min, maximum flow;
- elution: 3×3 ml of dichloromethane, flow: 0.5 ml/min.

Collected filtrates were evaporated using a vacuum evaporator (IKA RV 05 basic, IKA WERKE GMBH & CO.KG, Staufen) up to 1 ml. Evaporated filtrates were subjected to the chromatographic analysis performed for the conditions as for the determination of PAHs content. The content of eluted PAHs and elements was related to dry mass of the rubber granulate in each sample.

The devices were calibrated and checked on a current basis, including the analysis of control samples, before starting the measurements. Calibrations of the chromatograph, spectrometer and mercury analyzer were performed on solutions of certified reference materials and 2 control samples. The correlation coefficients obtained during the calibration were above 0.995 for all analyzed substances. The analysis of the control samples confirmed the accuracy of the calibration curves, which are the basis for the calculations. Measurements of the content/leachability of the tested substances were carried out for two parallel samples and a reagent blank sample, taking into account the results obtained from it in the analysis of analytical samples. The arithmetic mean of two parallel determinations was assumed as the result of the analytical measurement. Content/leachability conversions of test substances were performed using the GC–MS/MS MassHunter Workstation Software, LCP MHLauncher HPLC-ICP-MS and ACP-MS software and WinLab32 with an AA mercury analyzer FIMS100.

Results

The conducted tests showed the presence of PAHs in 47 tested rubber granules. Among the granulates with PAHs, 72% were SBR granules and 28% were EPDM granules. The leached elements was found in 44% of the examined granules, including 88% of SBR granules and 12% of EPDM granules. The summarized number of

	Number of tested granulate samples		Number of granulate samples where substances were detected		
	SBR	EPDM	SBR	EPDM	
PAHs content	14	3	5	1	Granules from the surface of sport fields
Leached elements	14	3	7	0	
PAHs content	43	24	29	12	Granules supplied by recyclers
Leached elements	0	1	0	1	

Table 3. Summarized number of granulate samples in which PAHs content and leached elements were detected.

	Content, mg/kg															
	BaP		BeP		BaA		CHR		BbFA		BjFA		DBAhA		BkFA	
Sample	x	U	x	U	x	U	x	U	x	U	x	U	x	U	x	U
SSF-1	ND	–	5.81	±2.19	3.94	±1.09	12.0	±3.7	ND	–	ND	–	0.96	±0.30	ND	–
SSF-2	3.15	±0.89	2.54	±0.96	4.85	±1.34	9.96	±3.15	ND	–	ND	–	0.53	±0.19	ND	–
SSF-3	2.59	±0.58	4.90	±1.83	2.09	±0.59	8.30	±2.67	ND	–	ND	–	0.71	±0.23	ND	–
SSF-4	2.51	±0.77	4.03	±1.62	1.56	±0.56	3.99	±1.45	2.57	±1.25	ND	–	ND	–	0.98	±0.40
SSF-5	4.32	±0.97	7.67	±2.85	3.23	±0.88	8.77	±3.38	ND	–	ND	–	ND	–	2.36	±0.89
ESF-1	ND	–	ND	–	ND	–	15.3	±4.50	ND	–	ND	–	ND	–	ND	–
SR-3	ND	–	ND	–	3.94	±1.54	10.7	±3.3	ND	–	ND	–	ND	–	ND	–
SR-4	ND	–	ND	–	ND	–	0.86	±0.30	ND	–	ND	–	ND	–	ND	–
SR-6	ND	–	12.3	±4.8	ND	–	ND	-	ND	–	ND	–	21.0	±6.8	ND	–
SR-12	1.61	±0.34	2.49	±0.90	ND	–	5.62	±1.80	ND	–	ND	–	ND	–	ND	–
SR-13	4.62	±1.04	6.35	2.37	3.22	±0.68	9.46	±3.03	5.20	±2.18	1.71	±0.93	ND	–	2.01	±0.51
SR-14	3.80	±2.10	6.37	3.56	2.20	±1.62	8.13	±7.70	4.16	±3.93	1.12	±0.97	ND	–	1.62	±0.81
SR-15	1.46	±0.44	2.55	1.04	ND	–	ND	–	ND	–	ND	–	ND	–	ND	–
SR-16	ND	–	ND	–	ND	–	21.1	±6.8	6.34	±2.61	0.26	±0.13	ND	–	ND	–
SR-17	9.24	±2.02	ND	–	ND	–	ND	–	4.84	±1.95	1.04	±0.46	ND	–	ND	–
SR-27	2.88	±0.81	3.75	1.61	ND	–	8.58	±2.97	ND	–	ND	–	ND	–	ND	–
Mean	3.62	–	5.34	–	3.13	–	9.44	–	4.62	–	1.03	–	5.81	–	1.74	–
Median	3.02	–	4.90	–	3.23	–	8.77	–	4.84	–	1.08	–	0.84	–	1.82	–
Min	1.46	–	2.49	–	1.56	–	0.86	–	2.57	–	0.26	–	0.53	–	0.98	–
Max	9.24	–	12.29	–	4.85	–	21.12	–	6.34	–	1.71	–	21.03	–	2.36	–

Table 4. The content of BaP, BeP, BaA, CHR, BbF, BjF, DBahA, BkF in rubber granules. *ND* not detected.

granulate samples, in which the content of PAHs and leached elements were detected in relation to their types and sources of origin, is presented in Table 3.

The content of PAHs in rubber granules. Detailed results of the research on PAHs content in granules are presented in Tables 4 and 5. Table 4 shows the results for BaP, BeP, BaA, CHR, BbFA, BjFA, DBAhA and BkFA. Table 5 shows the results for BghiP, naphthalene, phenanthrene, anthracene, IcdP, fluoranthene and PYR. The following abbreviations are used in the tables: SSF—a sample of SBR granules from a sport field, ESF—a sample of EPDM granules from a sport field, SR—SBR granulate sample provided by the recycler, x—average value, U—value of the expanded uncertainty at the confidence level of 95% and the expansion factor k = 2.

By analysing the results of the tests in Tables 4 and 5, it can be concluded that in 5 SBR granules from sport fields, 4 to 6 types of PAHs were found in the total content ranging from 15.6 to 26.4 mg/kg. The highest levels were recorded for CHR (12.0 mg/kg), BeP (7.70 mg/kg) and BaA (4.30 mg/kg). The BkFA content did not exceed 2.5 mg/kg and the DBAhA did not exceed 1 mg/kg. In the above-mentioned granules no BjFA was found.

In the case of one EPDM sample from sport field, the CHR content was 15.3 mg/kg. No PAH was found in the remaining samples of EPDM granules from sport fields.

In 29 SBR rubber granules, supplied by recyclers, from 1 to 13 types of PAHs were found, in the total content ranging from 0.86 to 172 mg/kg. In the SBR samples were present: PYR (22 samples), BghiP (21 samples) and naphthalene (21 samples), fluoranthene (19 samples). The remaining PAHs types were found in 19 tested granulate samples. PYR (165 mg/kg), fluoranthene (53.2 mg/kg) and BghiP (31.5 mg/kg) were in the highest content

Sample	Content, mg/kg													
	BghiP		naphthalene		phenanthrene		anthracene		IcdP		fluoranthene		PYR	
	x	U	x	U	x	U	x	U	x	U	x	U	x	U
SR-3	6.90	±1.50	1.70	±070	6.80	±2.50	7.40	±1.10	ND	–	11.6	±1.4	ND	–
SR-13	ND	–	0.22	±0.11	10.7	±3.5	0.91	±0.17	21.8	±6.5	14.6	±2.8	29.8	±7.4
SR-14	ND	–	0.27	±0.17	10.9	±3.7	0.72	±0.15	22.7	±5.5	11.6	±5.6	27.4	±7.3
SR-15	ND	–	ND	–	5.93	±2.30	0.47	±0.10	17.8	±4.4	6.49	±1.1	22.6	±4.7
SR-16	21.4	±6.1	0.77	±0.34	ND	–	4.06	±0.73	ND	–	34.3	±11.6	79.0	±10.8
SR-17	25.7	±6.8	1.18	±0.48	ND	–	ND	–	8.86	±2.09	ND	–	ND	–
SR-18	9.59	±2.89	2.71	±1.05	ND	–	ND	–	ND	–	ND	–	98.3	±15.9
SR-19	3.85	±1.17	1.72	±0.70	ND	–	ND	–	1.36	±0.46	ND	–	165	±25
SR-20	1.30	±0.36	1.78	±0.85	19.6	±16.5	20.2	±17.0	ND	–	ND	–	29.8	±5.2
SR-21	ND	–	1.62	±0.66	ND	–	1.63	±0.27	ND	–	ND	–	ND	–
SR-22	7.32	±1.79	1.42	±0.64	ND	–	ND	–	ND	–	8.15	±1.19	ND	–
SR-23	24.2	±8.3	1.36	±0.55	ND	–	ND	–	ND	–	24.4	±4.9	74.0	±23.1
SR-24	29.0	±7.7	1.38	±0.57	ND	–	ND	–	ND	–	31.8	±5.3	29.1	±9.7
SR-25	26.3	±4.9	1.46	±0.64	ND	–	5.75	±1.31	ND	–	41.3	±14.4	ND	–
SR-26	31.5	±10.2	1.70	±0.70	ND	–	9.75	±2.52	ND	–	53.2	±21.2	31.5	±12.2
SR-27	1.93	±1.20	ND	–	3.24	±1.32	6.45	±1.10	1.64	±1.25	34.7	±11.3	108	±34
SR-30	10.6	±4.0	0.30	±0.20	20.4	±3.2	ND	–	ND	–	ND	–	44.6	±12.8
SR-31	11.7	±4.9	0.50	±0.20	19.6	±5.4	ND	-	ND	–	ND	–	50.8	±25.3
SR-32	9.60	±2.2	0.40	±0.20	ND	–	ND	–	ND	–	16.6	±3.2	47.2	±21.0
SR-33	9.60	±2.2	0.30	±0.20	ND	–	ND	–	ND	–	19.6	±2.4	11.7	±3.9
SR-34	10.3	±2.3	0.40	±0.20	8.40	±2.90	ND	–	ND	–	14.8	±5.4	44.7	±14.9
SR-35	10.2	±2.3	0.40	±0.20	11.8	±3.2	ND	–	ND	–	18.6	±8.3	49.5	±16.2
SR-40	10.5	±3.6	0.60	±0.30	ND	–	ND	–	ND	–	25.7	±13.8	82.7	±31.8
SR-41	12.8	±1.3	ND	–	ND	–	ND	-	ND	–	18.8	±3.3	65.0	±23.6
SR-42	ND	–	ND	–	ND	–	ND	–	ND	–	7.61	±1.22	31.1	±6.4
SR-43	20.8	±2.5	ND	–	1.70	±0.77	3.09	±0.65	ND	–	24.6	±5.7	56.1	±6.2
ER-8	8.30	±1.8	ND	–	ND	–	ND	–	ND	–	14.7	±2.8	31.6	±5.8
ER-10	11.5	±2.7	ND	–	ND	–	ND	–	ND	–	ND	–	11.9	±2.8
ER-11	5.58	±1.31	1.34	±0.58	ND	–	ND	–	ND	–	6.54	±1.44	ND	–
ER-12	3.49	±1.26	1.47	±0.61	ND	–	ND	–	ND	–	9.40	±1.04	ND	–
ER-13	ND	–	1.63	±0.70	1.29	±0.74	ND	–	ND	–	9.18	±4.04	ND	–
ER-14	ND	–	1.47	±0.96	1.57	±0.61	ND	–	ND	–	9.50	±1.08	ND	–
ER-15	ND	–	0.99	±0.49	ND	–	ND	–	ND	–	ND	–	ND	–
ER-16	ND	–	0.90	±0.46	ND	–	ND	–	ND	–	ND	–	ND	–
ER-17	24.2	±6.3	0.97	±0.51	ND	–	5.96	±1.00	ND	–	53.8	±14.6	169	±40
ER-18	21.0	±7.5	1.31	±0.41	2.02	±0.85	2.43	±0.45	ND	–	ND	–	134	±22
ER-19	4.00	±1.28	1.35	±0.56	ND	–	ND	–	ND	–	6.09	±1.26	67.3	±19.7
ER-20	ND	–	1.17	±0.60	ND	–	ND	–	ND	–	ND	–	ND	–
Mean	13.3	–	1.12	–	8.85	–	5.29	–	12.4	–	20.3	–	61.2	–
Median	10.4	–	1.31	–	7.62	–	4.06	–	13.3	–	15.7	–	48.3	–
Min	1.30	–	0.22	–	1.29	–	0.47	–	1.36	–	6.09	–	11.7	–
Max	31.5	–	2.71	–	20.4	–	20.2	–	22.7	–	53.8	–	169	–

Table 5. The content of BghiP, naphthalene, phenanthrene, anthracene, IcdP, fluoranthene and PYR in rubber granules. *ND* not detected.

in the SBR granules. The lowest content were found for BjFA (less than 1.8 mg/kg). BjFA (less than 1.8 mg/kg) was the lowest content in the SBR granules.

In the case of 12 EPDM rubber granules supplied by recyclers, the presence of 1 to 5 types of PAHs were found in the total content ranging from 0.90 to 254 mg/kg. The most common was naphthalene (10 samples), BghiP (7 samples) and fluoranthene (7 samples). The remaining types of PAHs were found in 7 tested granulate samples. In the highest concentrations was PYR (169 mg/kg) and in the lowest concentrations was naphthalene (less than 2 mg/kg). No presence of BaP, BeP, BaA, CHR, BbFA, BjFA, DBAhA, BkFA, IcdP was found in this kind of granules.

The total PAHs content in the rubber granulate samples from a sport fields are shown in Fig. 4 and in the rubber granulate supplied by recyclers are shown in Fig. 5.

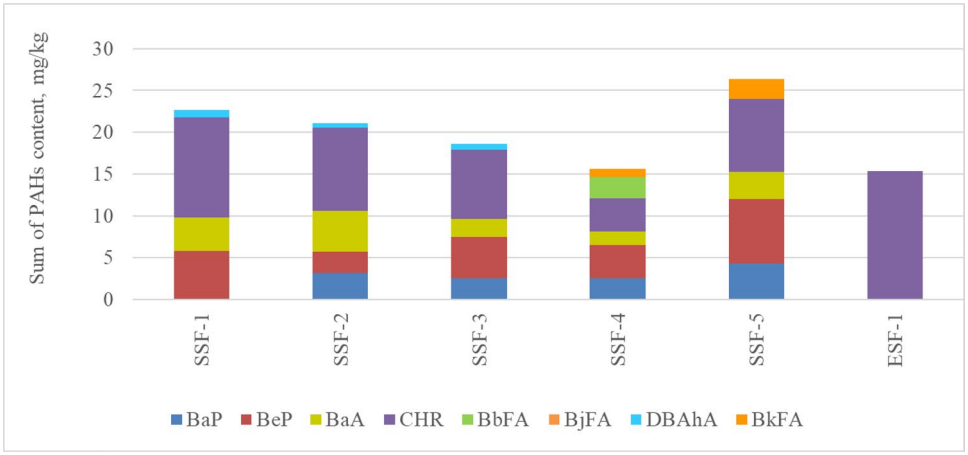

Figure 4. The sum of the PAHs content in the tested rubber granulate samples taken from the sport fields. *SSF* a sample of SBR granules from a sport field, *ESF* a sample of EPDM granules from a sport field.

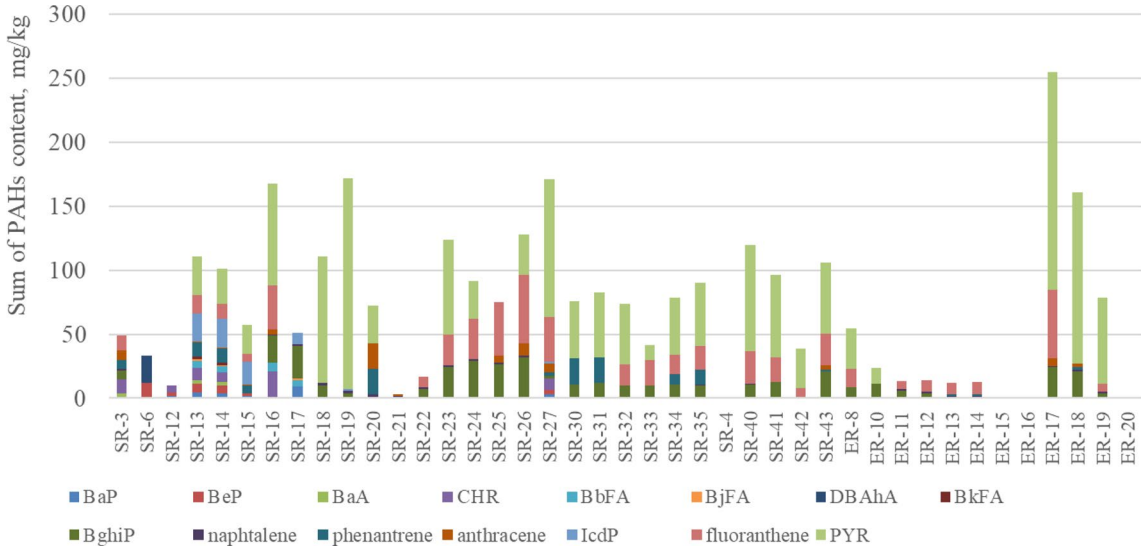

Figure 5. Sum of the PAHs content in the tested samples of rubber granules supplied by recyclers. *SR* SBR granulate sample provided by the recycler, *ER* EPDM granulate sample provided by the recycler.

The statistical parameters (median, Q1 and Q3 quartiles, mean, max and min) for the results of testing the PAHs content in rubber granules with a breakdown into particular types of PAHs are presented in Fig. 6. Due to the wide range of obtained results, a logarithmic scale was used.

Comparing the content of PAHs obtained from tests for SBR and EPDM granules from sport fields with the requirements specified in the REACH Regulation, the limit values for plastic and rubber products were exceeded for BaP, BeP, BaA, CHR, BbFA, BjFA, DBAhA and BkFA for 3 samples of SBR granules. When reference was made to the limit values contained in the AfPS GS 2019:01 PAK document, applicable in Germany, exceedances were found for 5 samples of SBR granules and for one sample of EPDM granules.

Comparative analysis of the results of tests for the content of PAHs in samples of SBR granules supplied by recyclers with the requirements specified in the REACH Regulation showed that the sum of BaP, BeP, BaA, CHR, BbFA, BjFA and BkFA was exceeded for 4 samples.

Comparing the PAHs content obtained from the tests for SBR and EPDM granulate samples provided by recyclers with the requirements of the[43], AfPS GS 2019:01 PAK document showed that the permissible values of the sum of 15 PAHs were exceeded for 28 samples of SBR granules and 10 samples of EPDM granules.

The elements and organotin compounds. Pb was leached from one sample and Cr (III) was leached from 7 samples out of 14 tested SBR granules from sport fields and one sample of EPDM granules supplied by the recycler. Leached Pb value exceeded 45 mg/kg, and Cr(III) ranged from 0.039 to 0.640 mg/kg. No other elements were washed from the tested granulate samples. The amount of leached organotin compounds did not exceed 6 mg/kg. Detailed results of element leaching tests concerning SBR and EPDM granules are presented in Table 6.

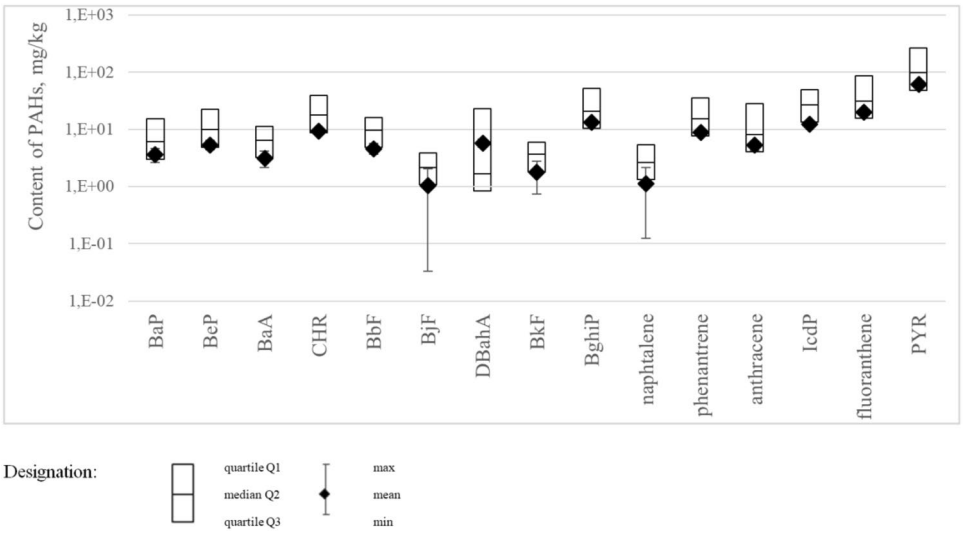

Figure 6. Statistical parameters for the results of tests for PAHs content in rubber granules.

Sample	Leaching, mg/kg			
	Pb		Cr(III)	
	x	U	x	U
SSF-1	ND	–	0.10	0.03
SSF-2	45	14	0.11	0.02
SSF-4	ND	–	0.059	0.022
SSF-11	ND	–	0.64	0.08
SSF-12	ND	–	0.17	0.03
SSF-13	ND	–	0.039	0.012
SSF-14	ND	–	0.14	0.09
ER-24	ND	–	0.10	0.05

Table 6. Results of research on the leaching of elements in SBR and EPDM rubber granules. *SSF* SBR granulate sample from a sport field, *ER* EPDM granulate sample provided by the recycler, *x* average value, *U* expanded uncertainty value with a confidence level of 95% and coverage factor k = 2, *ND* not detected.

Zn leachability, mg/l	SR40	SR41	SR42	ER17
Mean	0.238	0.266	0.143	0.004
Quantity	3	3	3	3
Median	0.286	0.238	0.107	0.003
Min	0.052	0.234	0.099	0.002
Max	0.375	0.326	0.224	0.006

Table 7. Results of leachability tests of Zn from SBR and EPDM rubber granules. *SR* SBR granulate sample provided by the recycler, *ER* EPDM granulate sample provided by the recycler.

Comparing the values of leached elements obtained from the tests for SBR and EPDM granulate samples with the requirements[47], the permissible value of leached lead was exceeded for one SBR sample from the sport field.

The PAHs and elements. The study of the leachability of PAHs and elements from rubber granules showed that in the case of 3 samples of SBR granules and one sample of EPDM granules, leached Zn was found. Detailed results of the Zn leachability tests from rubber granules are presented in Table 7.

For the tested three samples of SBR granules and one sample of EPDM granules, no leached remaining 6 elements: Cd, total Cr, Pb, Sn, Cr(VI), Hg was found, and 15 PAHs: BaP, DBAhA, BeP, BaA, CHR, BbFA, BjFA, BkFA, IcdP, BghiP, phenanthrene, anthracene, fluoranthene, PYR and naphthalene was not found, as well as.

Comparing the results of the Zn leaching tests obtained from the tests for SBR and EPDM granulate samples with the requirements[46], the permissible leaching value was not exceeded.

Summary and discussion

In order to evaluate the SBR and EPDM recycled rubber granules intended for the construction of sport field surfaces, 84 samples of granules were tested for PAH content, 21% of which were tested for the leaching of organic elements and compounds. Nearly 80% of the samples of granules tested for PAHs content were delivered for testing by recyclers, and the remaining 20% were taken from the surface of sport fields.

The test results of PAHs content. The tests showed the presence of PAHs in 56% of examined samples of rubber granules, among which the dominant share (34% of the tested samples) were SBR granules supplied by recyclers.

The obtained results of tests for the content of PAHs are consistent with the results of tests carried out by other researchers. The sum of the PAHs content in the tested granules supplied by recyclers reached the highest value of 172 mg/kg, similar to the research conducted by Llompart[24]. Lower values obtained from the tests of rubber granules collected from sport fields correlate with the results obtained by Celeiro[28] for rubber granules from 15 sport fields, Menichini[23] for rubber granules from 13 sport fields and Ruffino[48] for rubber granules from 5 sport fields. In the tested rubber granules used for the surface of sport fields, similarly to the granules tested by Llompart[24], Menichini[23] and Ruffino[48], in the rubber granules from dutch synthetic turf pitches[49], PYR, naphthalene and fluoranthene occurred most often and in the highest content. Low DBAhA contents were recorded in the granules tested by KOMAG Institute[50], by Llompart[24], Menichini[23] and included in the RIVM report[49], in contrast to the granules tested by Ruffino[48], where the DBAhA content was up to 8.13 mg/kg. The research of KOMAG Institute, as well as the research carried out by Menichini[23] showed a wide range of PAHs content, regardless the type and source of granules. The PAHs content in rubber granules depends on many factors, i.e. the quality of recycled waste, the duration of use of the granulate on the pitch, the frequency of its replacement and the type of material used for this purpose, according to Ref.[23].

The high PAHs content in granules from sport fields is particularly important due to the fact that they are used by children who are directly exposed to the granules while running on the pitch, jumping, slipping and falling. It should be noted that the physical activity of children on sport fields increases the rate of their metabolism, which translates into the intensity of absorption of toxic chemicals from the environment and may, consequently, lead to threats to their health. They are also shorter than adults, so they have easier access to these compounds.

The results of elements and organotin compounds leachability. The study on the elements and organotin compounds leaching from the granules used for sport fields showed a high amount of Pb leached from the granules in one case. The remaining examined elements were not extracted from the granules. These results differ from the results obtained by FA Group for SBR granules from artificial turf, which showed leached Zn at the level of 365 mg/kg, Cu at the level of 41 mg/kg and Al at the level of 6.15 mg/kg. The cause may be the lack of information about the source of the granules tested by FA Group[17].

Taking into account that the permissible value of the leached Pb was exceeded for statistically 5% of the tested granules, it can be concluded that the study on the elements leaching should be an important feature of the safety assessment of rubber granules used for the surface of sport fields.

The results of PAHs and elements leaching tests. The leaching tests of rubber granules used for sport fields showed small amounts of leached Zn for all of 3 SBR granules and 1 EPDM granulate specimen. The remaining 6 elements and 15 PAHs were not washed out from the tested rubber. The above results of the PAHs and elements leachability consistent with the results obtained by Gomes[22] and Bocca[20] for car tire granulates. The elution of Zn and the lack of elution of other elements from rubber granules from sport fields were also found by Kleps[33], Niesłochowski and Deptuła[26] and Nilsson[18]. In the case of tests carried out by Bocca[20] and by Kleps[33], the leaching of Zn was determined for two types of environmental conditions, with the use of deionized water and under acidic conditions (pH: 5). The leaching liquid with the reduced pH increased the leachability of zinc. It increased also leachability of Cd, Cr and Pb[20].

On the basis of the obtained test results, it was found that the rubber granules do not pose a threat to the natural environment due to the leaching of PAHs and elements. However, taking into account the size of rubber granules, which determines their classification as microplastics, polluting ecosystems and food chains. The content of PAHs is important due to the threats to living organisms.

Conclusions

Rubber waste, including waste from used car tires, is a significant and problematic stream of polymer waste in terms of quantity. They are used for the production of rubber granules for the surface of sport fields, among others. The assessment of recycled SBR and EPDM rubber granules, carried out as part of the study, showed that they contain harmful to human health PAHs in amounts exceeding the permissible limits. Extender oils and black carbon used in the manufacture of tires can be the source of PAHs in SBR granules[51–54]. This state of affairs is confirmed by the results of research conducted by other global research units and the new limitation in this regard introduced by the European Commission in July 2021, in the REACH Regulation. On the other hand, the preliminary studies on leaching, using methods used to assess the impact of waste on the environment carried out by the authors of this publication, showed that no harmful elements and PAHs were washed out from the tested rubber granules. In the light of literature reports on the increase of leached metals after using a liquid with lowered pH, equal to 5, it can be concluded that the standardized method of leaching the above-mentioned

with the deionized water does not reflect the actual leaching conditions in the environment in which the rubber granules are embedded. This method requires further development in terms of adjusting the parameters of the leaching liquid to them.

The results of the presented research may constitute the basis for undertaking work on the development of the application of rubber granules alternative to the surface of sport fields. In further works, the authors intend to analyze the possibility of reducing the risk associated with contamination of ecosystems and food chains with rubber granulate particles with an increased content of PAHs. There will be attempts to exemplify their application in construction or hydro construction. They are known to be used in bridge abutments, road embankments, reinforcing soil and roadsides, asphalt pavements, making retaining walls, vibro-insulation boards, soundproofing insulations, damping screens and paving stones[11,55–61].

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Author contributions

B.G.-B. contributed to the study conception, methodology and managed the project; B.R. and B.S.-S. contributed to data collection; B.G.-B. and B.R. prepared formal analysis and results interpreted; B.G.-B. led the writing of the manuscript; all authors contributed to the interpretation of the results and writing of the manuscript. All authors read and approved the final manuscript.

Competing interests

The authors declare no competing interests.

Additional information

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STAFF REPORT
SPECIAL MEETING

AGENDA DATE: May 9, 2024 **DEPARTMENT:** Community Sustainability

TITLE:

Scope of Services for tree planting services recommended by the Tree and Landscape Board

SUMMARY:

The Tree and Landscape Board was asked to develop the Scope of Services for tree planting in the City.

BACKGROUND AND JUSTIFICATION:

The City Commission and residents recognize the need for more shade trees and understory plantings throughout the City. At the September 12, 2023 Tree and Landscape Board meeting, a group of citizens called Neighbors Encouraging Shade Trees (NEST) asked the Board to recommend that the City Commission authorize the use of $25,000 from the Tree Canopy Restoration Fund (Tree Fund) to plant native shade trees in Bryant Park. The Board voted to recommend to the City Commission to allocate $25,00 from the Tree Fund and an additional $25,000 from other City funds to plant native shade trees. At the November 7, 2023 regular meeting, the Commission voted to authorize the use of $25,000 from the Tree Fund and $25,000 from ARPA funds to plant trees in Bryant Park. The Interim City Manager requested that the Tree and Landscape Board create the Scope of Services for professional landscape installation services.

MOTION:

Move to approve/disapprove the Scope of Services for Tree Planting from the Tree and Landscape Board.

ATTACHMENT(S):

Fiscal Impact Analysis
Scope of Services

FISCAL IMPACT ANALYSIS

Five Year Summary of Fiscal Impact:

Fiscal Years	**2024**	**2025**	**2026**	**2027**	**2028**
Inflows/Revenues					
Appropriated (Budgeted)	0	0	0	0	0
Program Income	0	0	0	0	0
Grants	0	0	0	0	0
In Kind	0	0	0	0	0
Outflows/Expenditures					
Appropriated (Budgeted)	$25,000	0	0	0	0
Operating	0	0	0	0	0
Capital	0	0	0	0	0
Net Fiscal Impact *(If not budgeted)*	0	0	0	0	0
No. of Addn'l Full-Time Employee Positions	0	0	0	0	0

Contract Award - Existing Appropriation (Budgeted)	
	Expenditure
Department	Beautification Fund
Division	Public Services
GL Description	Operating Supplies/ Landscaping
GL Account Number	190-5040-572.52-70
Project Number	AP2410
Requested Funds	$25,000
Remaining Balance	$25,000
Source of Revenue (i.e. Paygo. Current Revenue, Bond Money, Grants, etc.)	ARPA

GENERAL INFORMATION

1. PROJECT OBJECTIVE

To plant more native shade trees and native understory plantings in the City of Lake Worth Beach. City residents have expressed the need for more shade trees and understory plantings City-wide which is a shared value of the City Tree and Landscape Board. Over 60% of the respondents to the Mobility Plan Survey stated that they wanted more shade and trees along sidewalks. The addition of trees in the city will:

1. Increase shade and tree canopy
2. Reduce energy consumption by air conditioning
3. Reduce heat island effects
4. Reduce effects of climate change by increasing carbon capture
5. Increase habitat diversity
6. Encourage a more pleasing natural environment

The City of Lake Worth Beach is seeking qualifications from interested professional landscape installation companies/firms. The services required: a) provide and install native shade trees and native understory plantings using industry best management practices and ANSI A300 standard part 6, using qualified in-house staff and qualified contractor staff. b) Provide and deliver trees for city-wide tree giveaways. The selected Respondent will be chosen based upon their relevant expertise and thorough knowledge of the professional services, functions, activities, and related responsibilities to successfully deliver required services. A more detailed scope of services is attached and incorporated into this RFQ as Exhibit “A”.

2. SUBMITTAL OF QUALIFICATIONS

CITY WILL ADD BOILER PLATE LANGUAGE

EXHIBIT "A"

RFQ# xx-xx

SCOPE OF SERVICES

The CONTRACTOR shall be responsible for all aspects of this xx including but not limited to:

Tree and Shrub Planting

- Acquire, deliver and install high-quality native shade trees and native understory plantings
- Provide 25, 15, 7- and 3-gallon plant material as directed by City staff
- Provide and install staking materials
- Provide necessary equipment for tree planting and staking
- Water trees and understory plantings at time of planting.
- Tree planting to be supervised by qualified individual, Certified Arborist preferred.
- Ensure planting sites are free of debris and tools at conclusion of work day

Tree Giveaway

- Provide 15, 7- and 3-gallon plant materials
- Deliver plants to City on date of giveaways.

Notes

1) The City will provide direction on tree selection and understory plantings.

(2) The City reserves the right to reject trees that are of poor quality, damaged, poor structured, etc.

1. GENERAL STANDARDS OF WORK

1.1. **Schedule of Work:** At the beginning of each project, the CONTRACTOR shall furnish to the CITY a schedule of work. The City reserves the right to direct the CONTRACTOR to rearrange the schedule to meet the needs of the CITY.

1.2. **Maintenance of Traffic:** The CONTRACTOR shall be responsible for proper MOT control and monitoring of pedestrian and vehicular traffic as it pertains to this work.

1.3. **Utilities:** The CONTRACTOR shall be responsible to report any encountered damaged utilities and report/repair any damages associated with their work.

1.4. **Litter Control**: The CONTRACTOR shall be responsible for the pickup and collection of litter associated with the work in this RFQ. The litter shall be disposed of legally in CITY provided waste collection receptacles.

1.5. **Watering**: The CONTRACTOR shall be responsible for the initial watering of all planted material immediately after planting. Watering must be sufficient to remove all possible air pockets and to thoroughly soak the root ball and surrounding soils.

1.6. **Deficiencies**: The City will inform the CONTRACTOR of any deficiencies in the planting and/or staking of the trees and/or shrubs. CONTRACTOR will correct deficiencies within 48 hours of notification.

1.7. **The City reserves the right to decrease or amend any of the services as listed and described herein in negotiations with the selected firm**.

Location of projects

Various locations City-wide including parks, cemeteries, public buildings, greenways, golf course, rights-of-way

QUALIFICATIONS

The City is seeking a landscape company/firm with the following qualifications:

- Certified arborist on staff preferred
- Minimum of one supervisor and four field workers
- Experience in selecting and planting native trees and shrubs
- Provide equipment list needed in order to undertake scope of services
- Respondents shall provide a three-page summary of their ability to deliver the requested services in a specific timeframe, including a proposed project timeline. Information regarding dedicated staff and current workload should be provided.
- Related experience, projects completed and for whom (include photos and/or other documentation)
- Training, education and degrees
- Professional certifications, licenses and affiliations/memberships
- Three professional references required (not from family relatives)