“Water is the driver of nature
....so one might say
that it changes into as many natures
as are the different places through which is passes.
And as the mirror changes with the color of its objects
so this changes with the nature of the places it passes:
Health-giving, harmful, laxative, astringent,
sulphurous, salt, sanguine, depressed,
raging, angry, red, yellow, green, black, blue,
oily, thick, thin.
Now it brings conflagration, then it extinguishes;
is warm and is cold;
now it carries away, then it sets down,
now it hollows out, then it raises up,
now it tears down, then it establishes,
now it fills up and then it empties,
now it rises and then it deepens,
now it speeds and then lies still
....now it nourishes and then does the contrary,
now it is salt and then is without savor
…With time everything changes.”

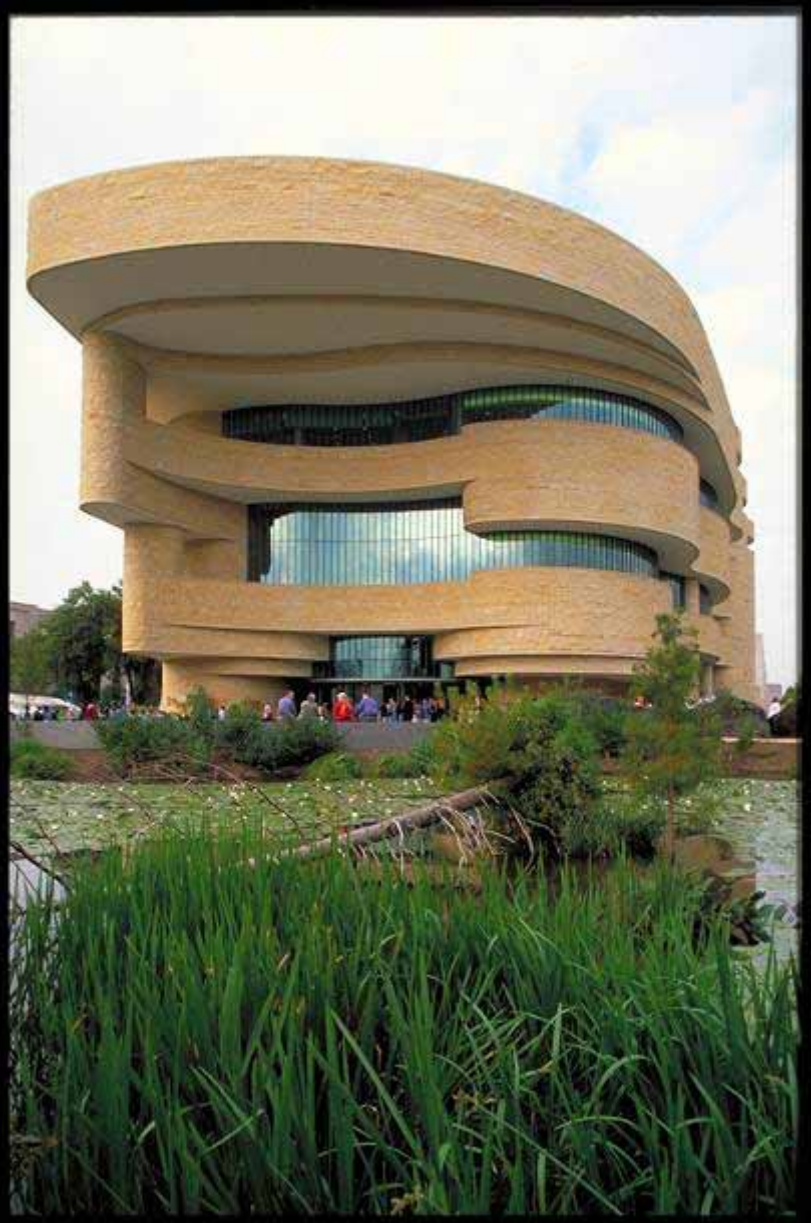
Leonardo da Vinci

The Details of Design

Dominic Shaw

Waterline Studios, Inc


Imperial
Bronzelite
Architectural Lighting & Fountains
DOMINIC SHAW
Systems Designer
P.O. BOX 606
San Marcos, Texas 78666
(512) 392-8957
A Division of Wickes Corporation
Imperial
Bronzelite
DOMINIC SHAW
Manager - Technical Sales
P.O. BOX 606
SAN MARCOS, TEXAS 78667
(512) 392-8957
Telex 776-479
FCI
Fountain
Consultants
International, Inc.
DOMINIC SHAW
PARTNER
2600 Stemmons Freeway
(214) 631-4804
WATERLINE
STUDIOS
Dominic Shaw
Director of Water Features
1321 Salem
Fort Collins, Colorado
80525
www.waterlinefountains.com
dshaw@waterlinefountains.com
T. 970.207.9697
F. 970.207.9698
M. 970.481.4534
Commercial
Waterfeatures
Inc.
(214) 631-5210
Dominic Shaw
General Manager
Dallas, Texas 75207
Bronzelite
LANDSCAPE & UNDERWATER LIGHTING
a GENLYTE company
DOMINIC SHAW
PRODUCT SALES MANAGER
P. O. BOX 606
SAN MARCOS, TEXAS 78667
(512) 392-5821 1(800) 235-2314
FAX (512) 753-1122
Waterscape Designs, Inc.
FOUNTAIN CONSULTING
DOMINIC SHAW
PRESIDENT
2612 McGregor Drive
Austin, Texas 78745
Phone: 512-462-9783
Fax: 512-462-9783
Domshaw@aol.com
DOMINIC SHAW
DIRECTOR OF WATER FEATURE DESIGN
EDAW
EDAW INC
240 EAST MOUNTAIN AVENUE
FORT COLLINS COLORADO
80524
TEL 970 484 6073
FAX 970 484 6518
shawd@edaw.com



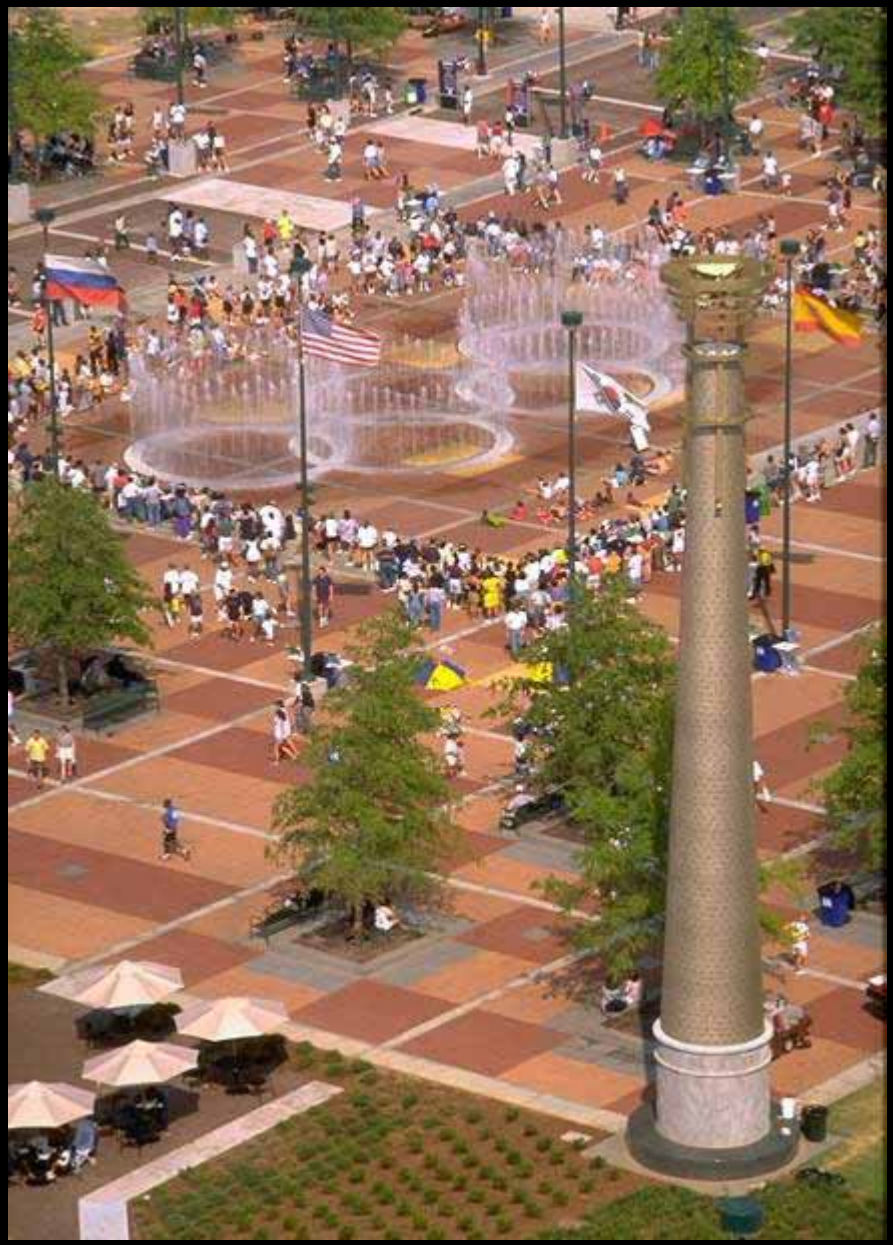
Water Feature Costs

- Average water feature costs is between $200-300k
- Assumes:
  - Basic pool shape and finishes
  - Standard water effects, nozzles or waterfalls
  - Standard lighting
  - No interactive components
  - < 100’ distance to equipment space

$135,000

$500,000

$2,000,000



$35,000,000

Understanding the Medium
or
All about Water

- **Terminology**
  - **Knowing the difference between water effects**
- **Execution of effects**
  - **In order to execute you need to know how they work**
- **How to make them work**
  - **The devil in the details**
- **Knowing the details**
  - **Construction methods and tolerances**

Types of Waterfalls

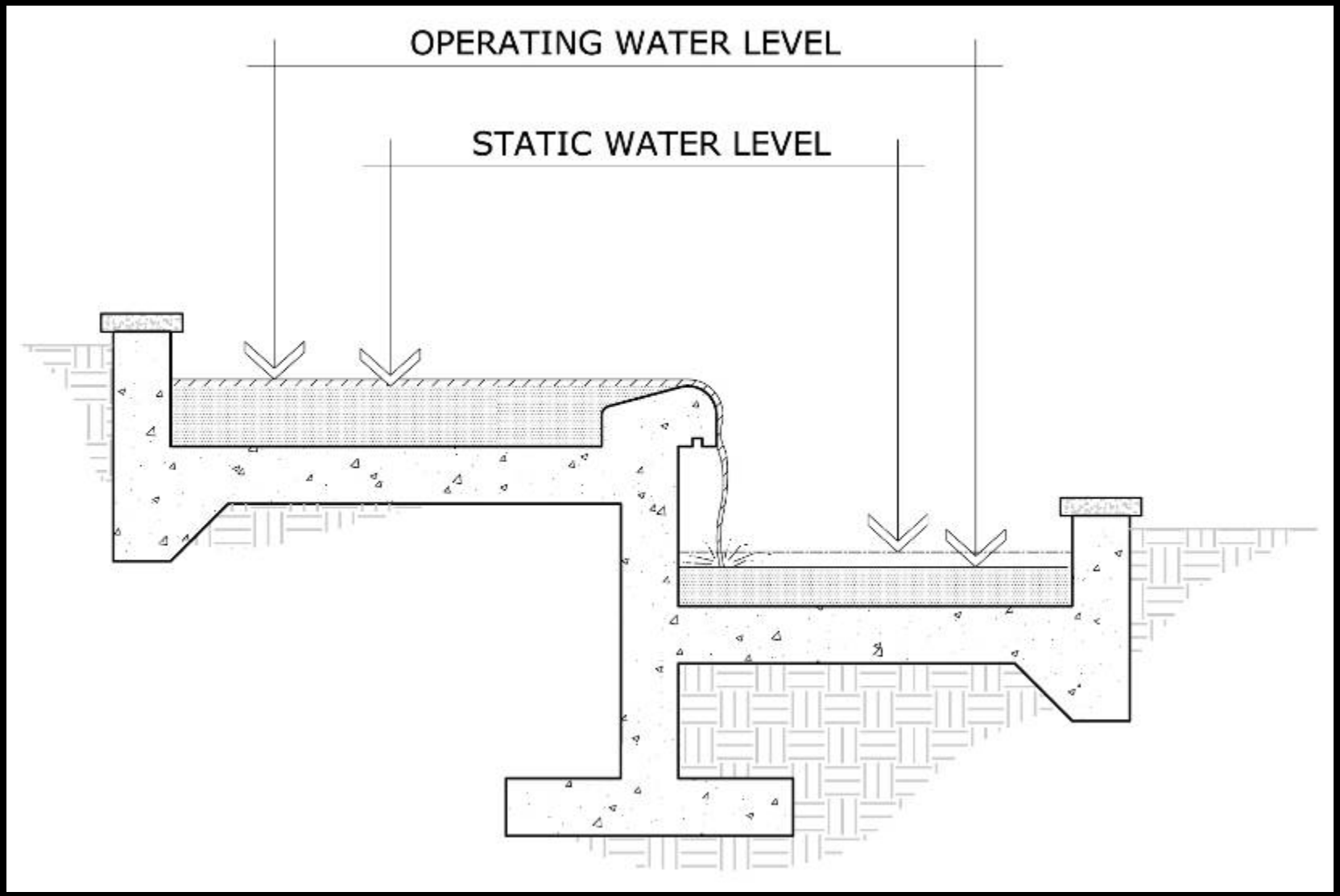
- Cascades – heavy flows and falls
- Steps – aerated white water
- Veils or Sheet falls – smooth flows
- Waterwalls
  - Aerated – contained white water
  - Textured – controlled roll waves
  - Tension – smooth wave patterns

Hydraulic Design

- **Waterfalls**
  - **Types: Smooth Sheets, Cascades, Steps, Waterwalls require different flow rates and physical arrangements**
  - **Flow requirements are per lineal foot but knowledge of how this translates into flow depth is important**
  - **Weir design is very important to the execution of any given water effect**

Flow rates for water depths

- 1/8” depth = 5 gpm per lineal foot
- 1/4” depth = 10 gpm per lineal foot
- 1/2” depth = 17 gpm per lineal foot
- 3/4” depth = 28 gpm per lineal foot
- 1” depth = 40 gpm per lineal foot
- 1.5” depth = 70 gpm per lineal foot
- 2” depth = 105 gpm per lineal foot

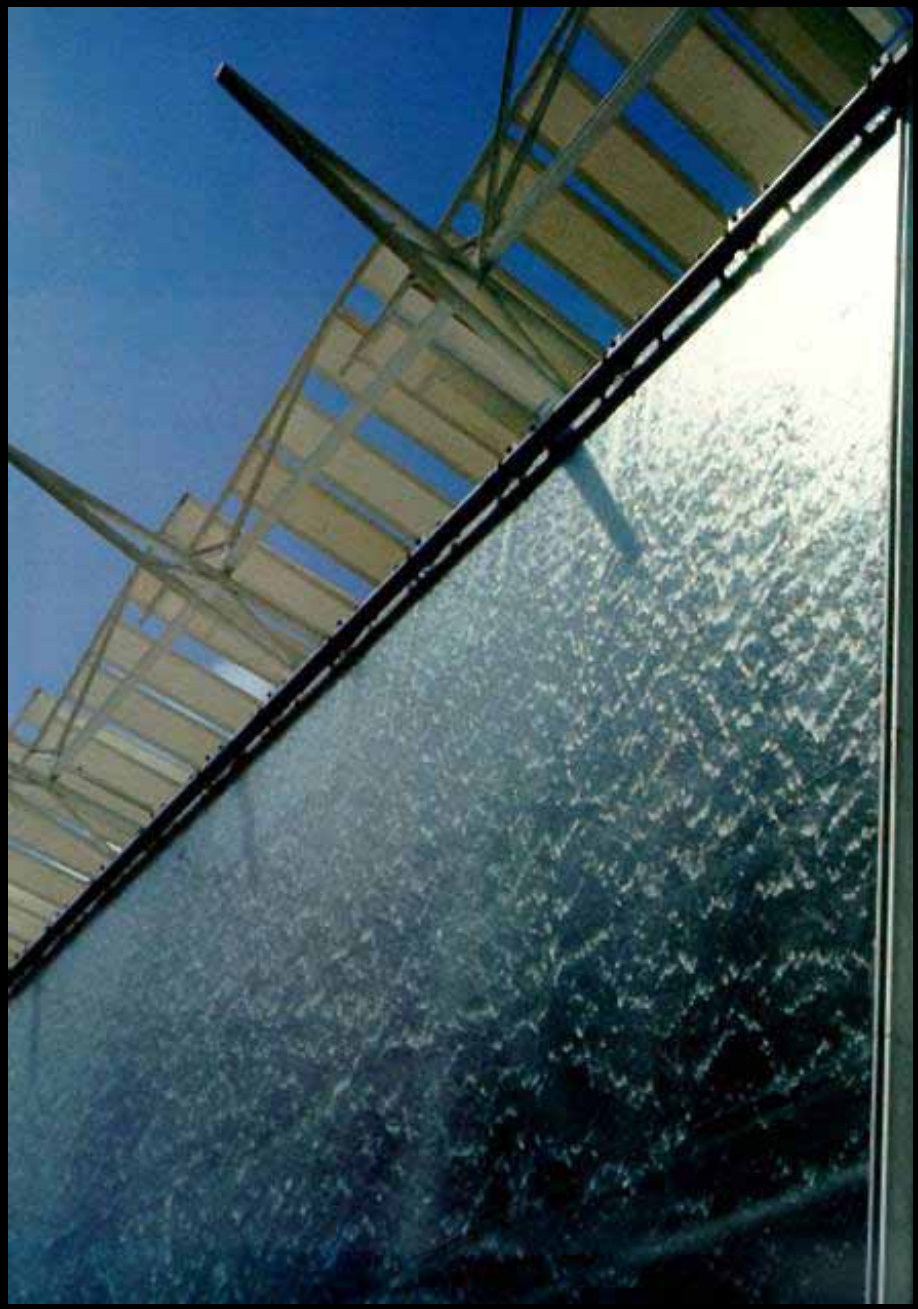

OPERATING WATER LEVEL
STATIC WATER LEVEL

Shut Down Rise

- Area of upper pool ($ft^{2)}$ x Depth of water (ft) = volume of water to catch (ft^3)
- Volume of water to catch (ft^3) ÷ Area of lower pool = Shut down rise (ft)
  - Example:
  - Upper pool size 10 x 20 = 200 sq. ft.
  - Lower pool size 20 x 4 = 80 sq. ft.
  - Flow over waterfall = 1” = .083’
  - 200 sq. ft x .083 ft = 16.6 cu. ft.
  - 16.6 cu. ft. ÷ 80 sq. ft = .2075’ = 2.49”

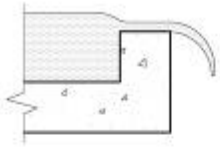
Laminar Flow

- Non turbulent, non crossing flow – with a Reynolds number of 2000 or less
  - Stable in nozzles
  - Stable in water falls
  - Usually does not occur in pipes larger than ¾”

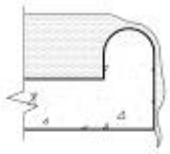


Weir

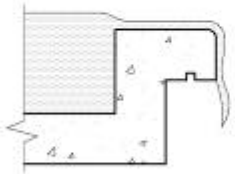
- A dam used to hold back or set the elevation of a waterway.
  - Types of weirs
    - Blade weirs
    - Broad crested weirs
    - Broad crested with end contractions
    - Round crested
    - Sharp crested
    - Notch weirs, comb weirs, filigree



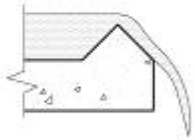
SHARP-CRESTED



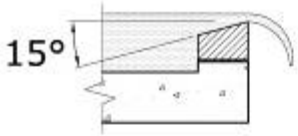
ROUND-CRESTED



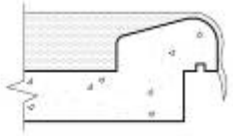
BROAD-CRESTED
DEPRESSED NAPPE



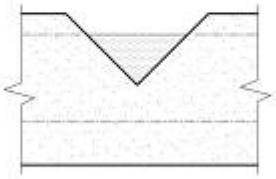
TRIANGULAR-CRESTED



SHARP-CRESTED
CORRECT
CONFIGURATION

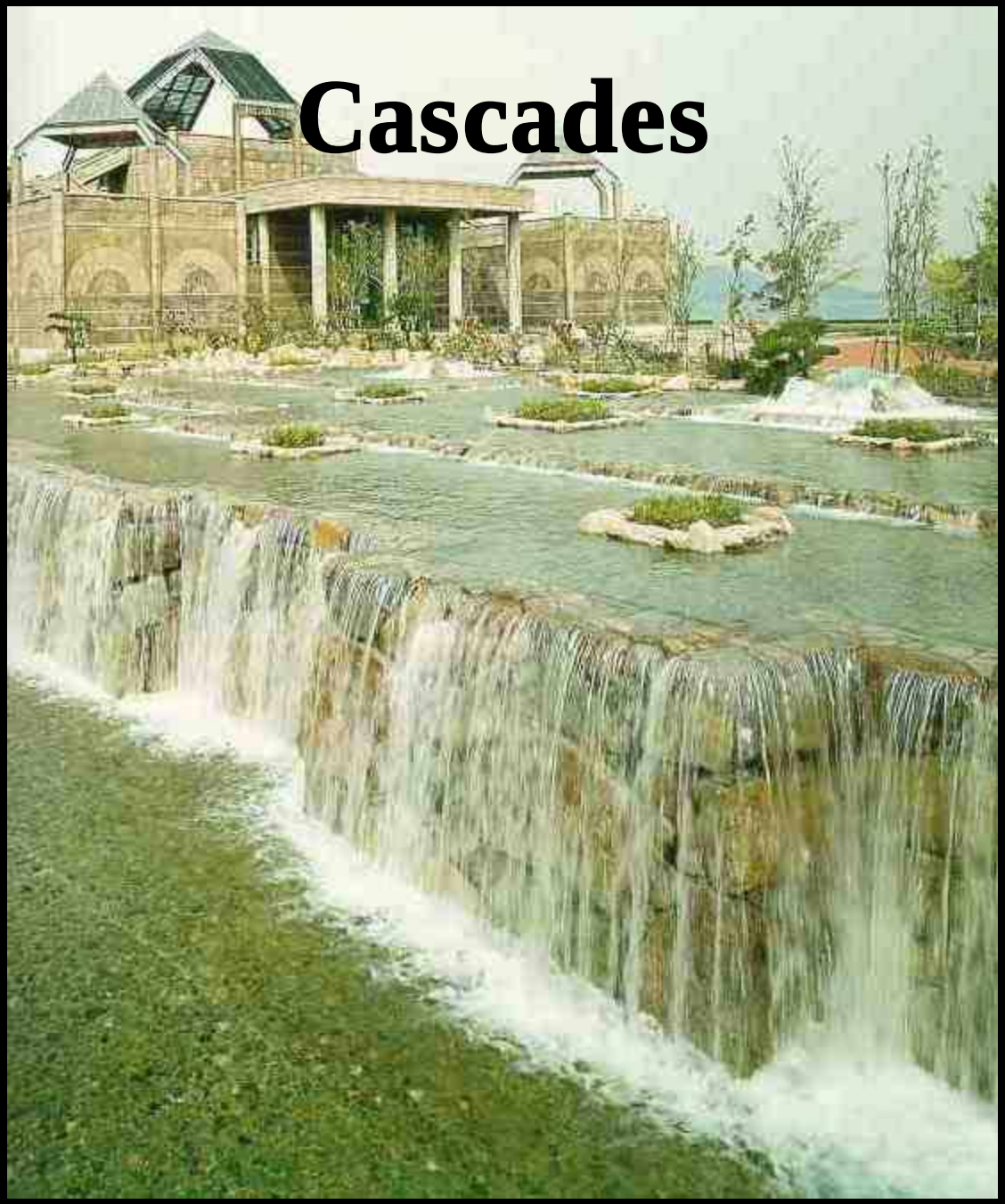


ROUND-BROAD-CRESTED



V-NOTCHED
(FRONT-ELEVATION)

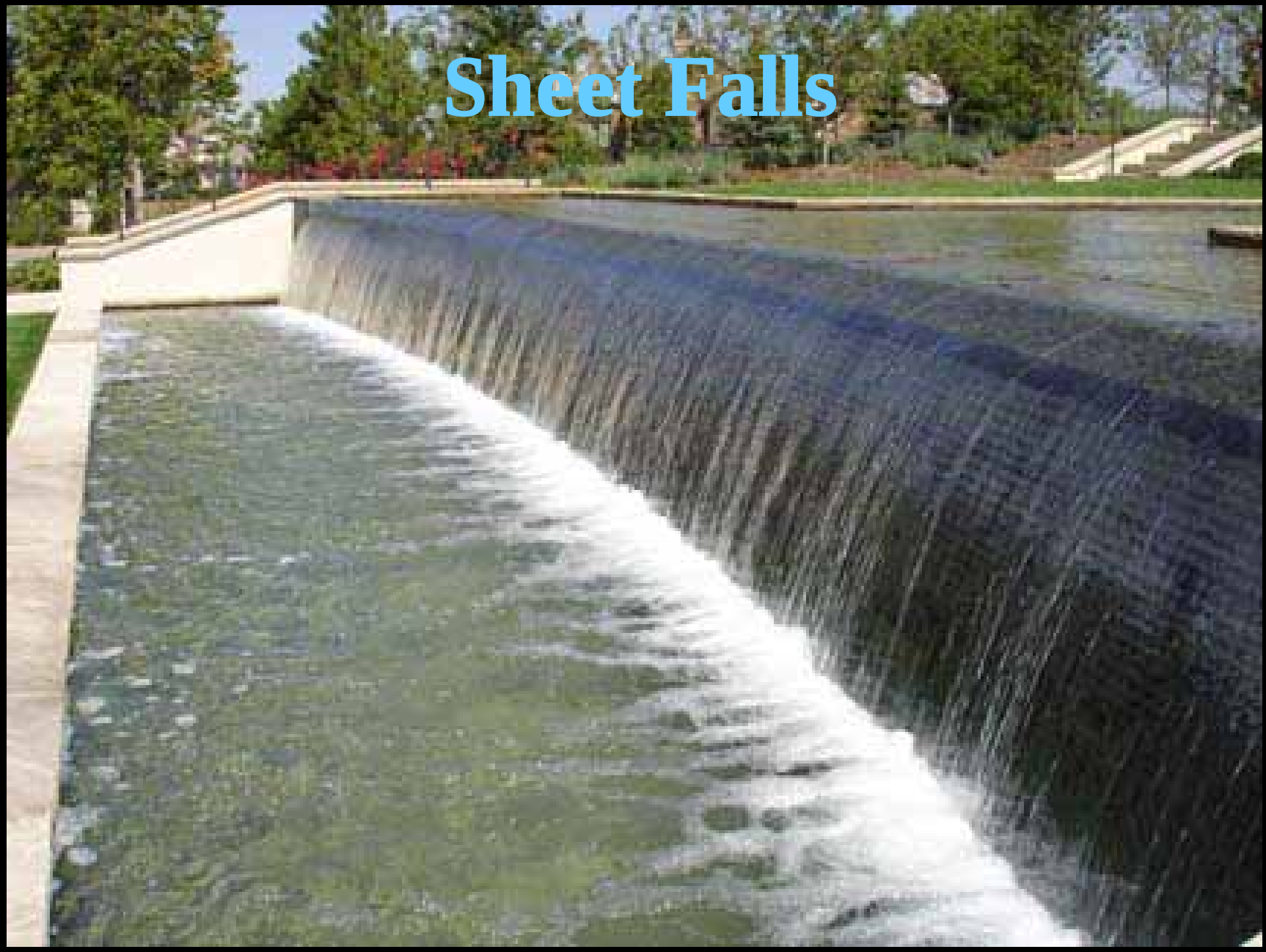
Cascades



Cascades

- Easiest to execute because of weir tolerances
- Tolerant to turbulence
- Works with all types of stone finishes
  - Stone finish types:
    - Polished – smooth
    - Honed – just under polished
    - Thermal/flamed/exfoliated – coarse texture from heat
    - Sawn – rough cut
    - Split face – rough cleave

Sheet Falls

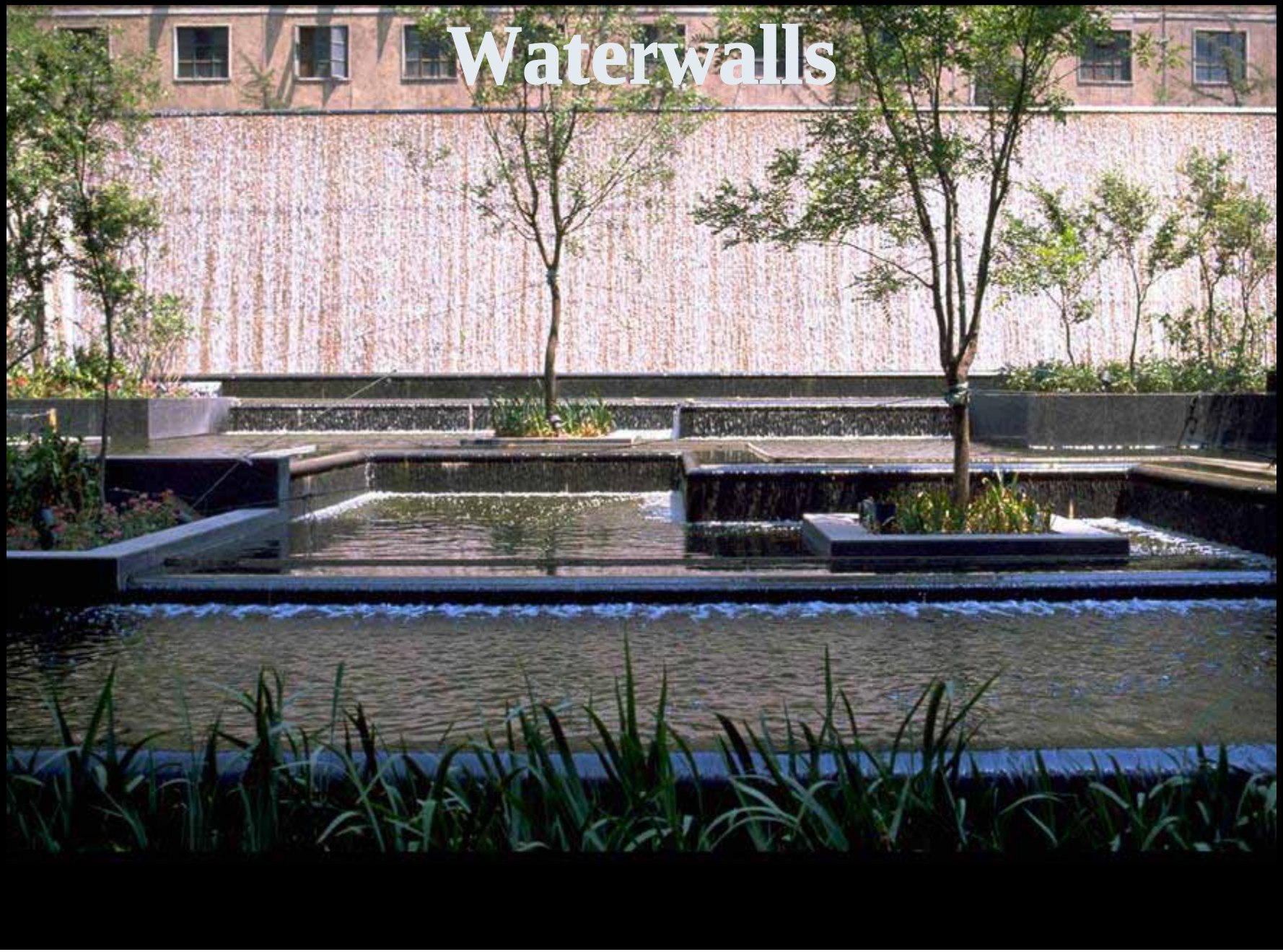


Sheet Falls

- Most difficult to execute
- Smooth approach velocity required
- No turbulence
- Proper weir profile
- Proper flow volume
- Max height 10-12 feet

Waterfalls

- **Flow requirements:**
  - **Cascades:**
    - **Over cut stones or concrete allow up to 35 gpm per foot**
    - **Over coarse or natural stone allow up to 50 gpm per foot**
  - **Smooth Sheets:**
    - **3-5’ fall allow 40 gpm per foot**
    - **5-10’ fall allow 100 gpm per foot**
    - **10-12’ fall allow 150 gpm per foot**

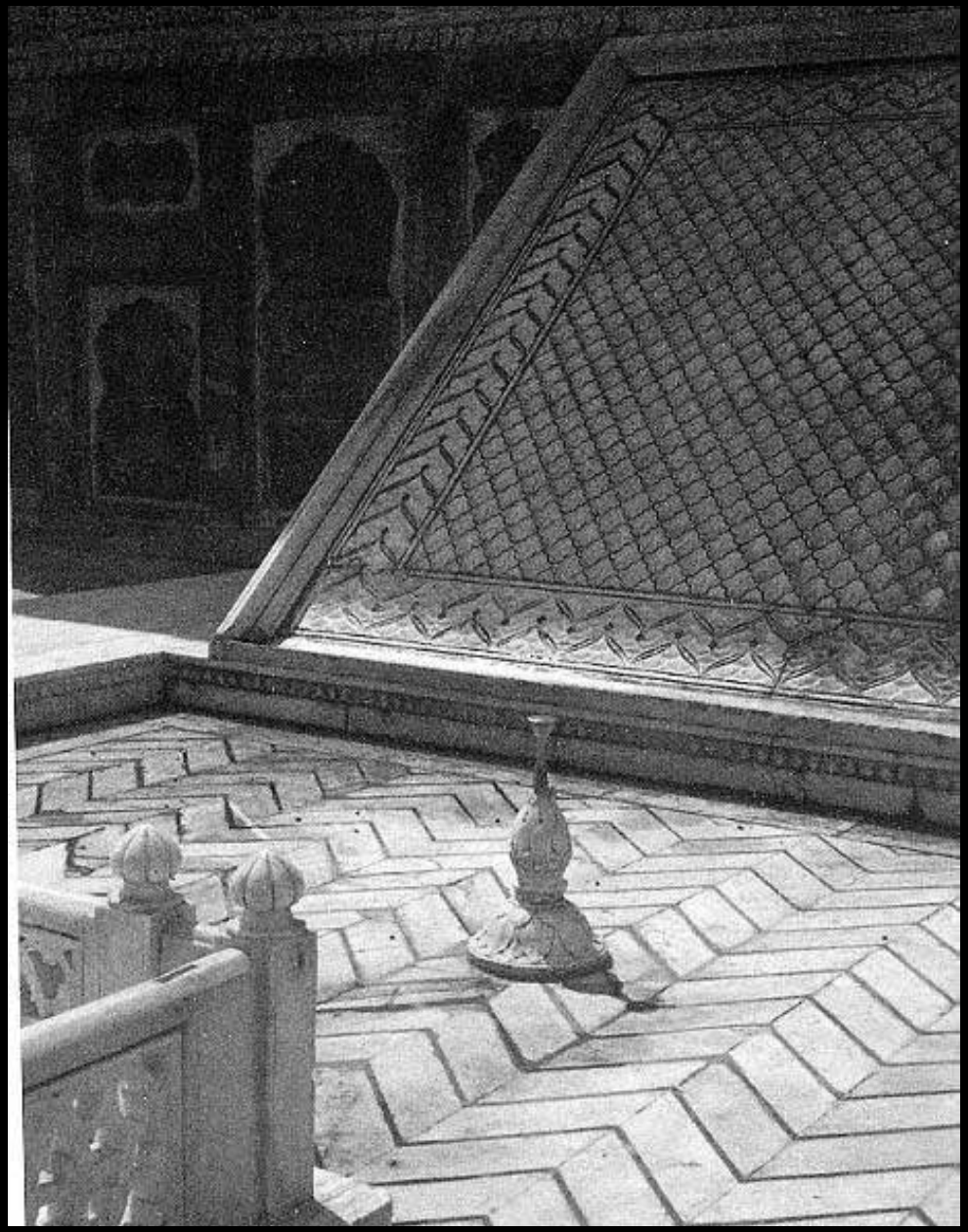

Waterwalls

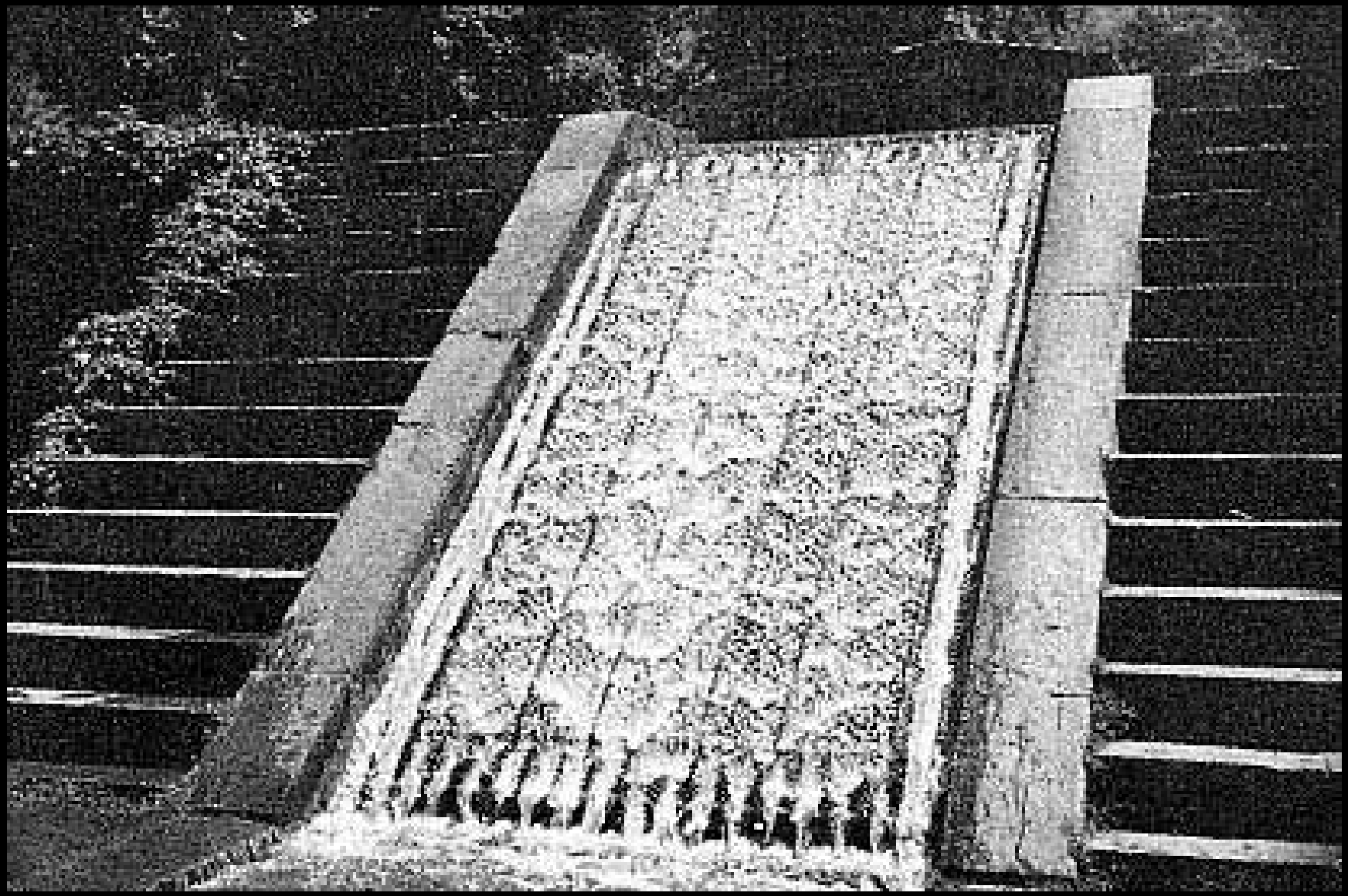
Waterwalls

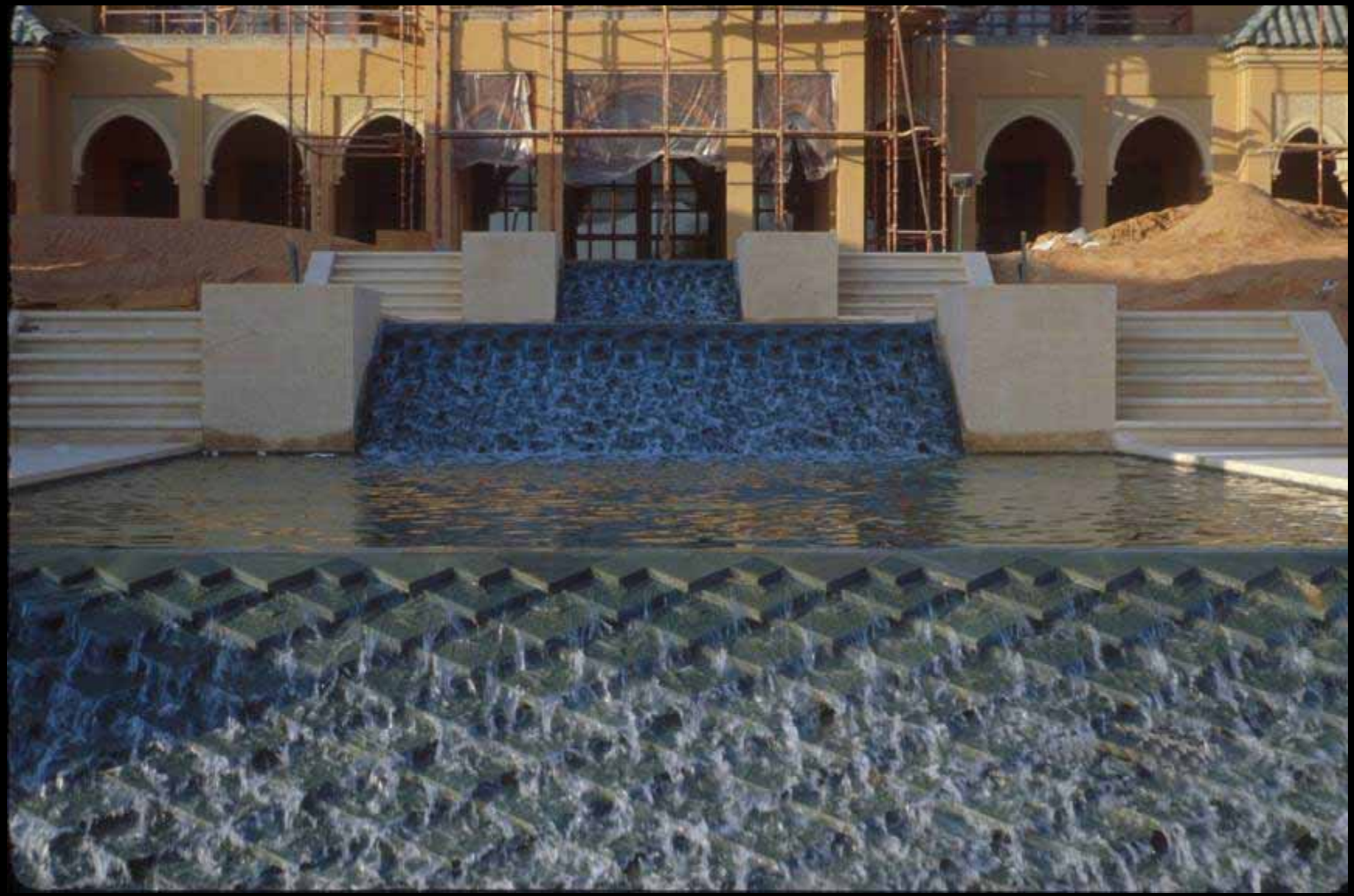
- **Aerated – textured rough surface – white water look**
- **Tension – smooth surface – surface waves**
- **Textured – tooled surface – roll waves**
- **Chadar – textured, tiled or tooled and battered – moderate white water or textured water**

Chadar: *n,* a cloth used for head covering by Hindu and Muslim women

Batter: n, a backward or upward slope of a wall or the like







Flows for Waterwalls

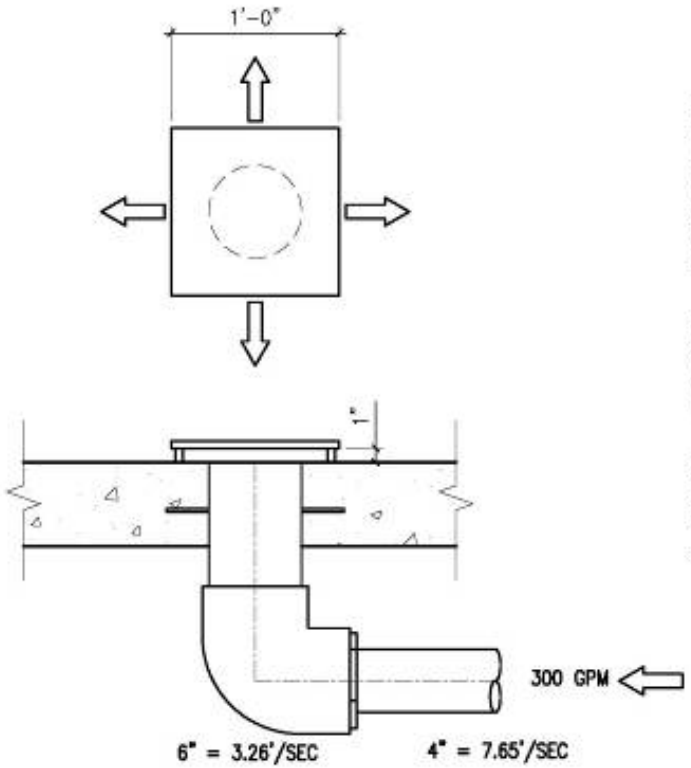
- **Aerated waterwalls - up to 35 gpm per lineal foot**
- **Tension and textured waterwalls - 4-8 gpm per lineal foot**


1.090
Bottom

Designing for velocity and turbulence

- Discharge velocity has to be controlled with proper pipe and fitting sizing
- Velocity calculation
  - GPM ÷ 60 = gallons per second
  - GPS ÷ 7.48 = cubic ft. per second
  - FT^3 ÷ open area of fitting (ft^2) = feet per second
- Gallons ÷ 7.48 = cubic feet
- Open area in sq. inches ÷ 144 = sq. feet
- Typically design for 3’/sec from fittings

Figuring velocity



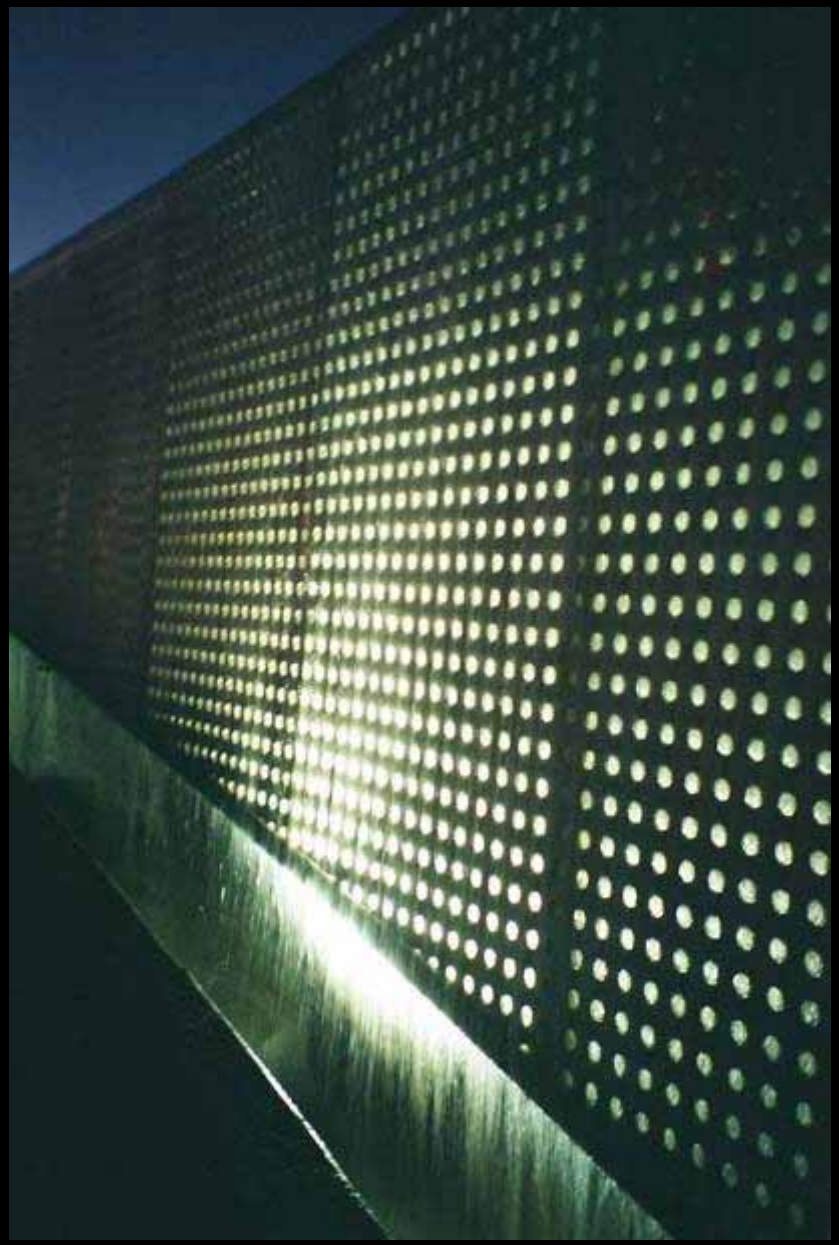
PERIMETER = 12"
12" X 4 SIDES = 48"
OPENING = 1"
OPEN AREA = 48 IN^2
48 IN^2 ÷ 144 = .33 FT^2

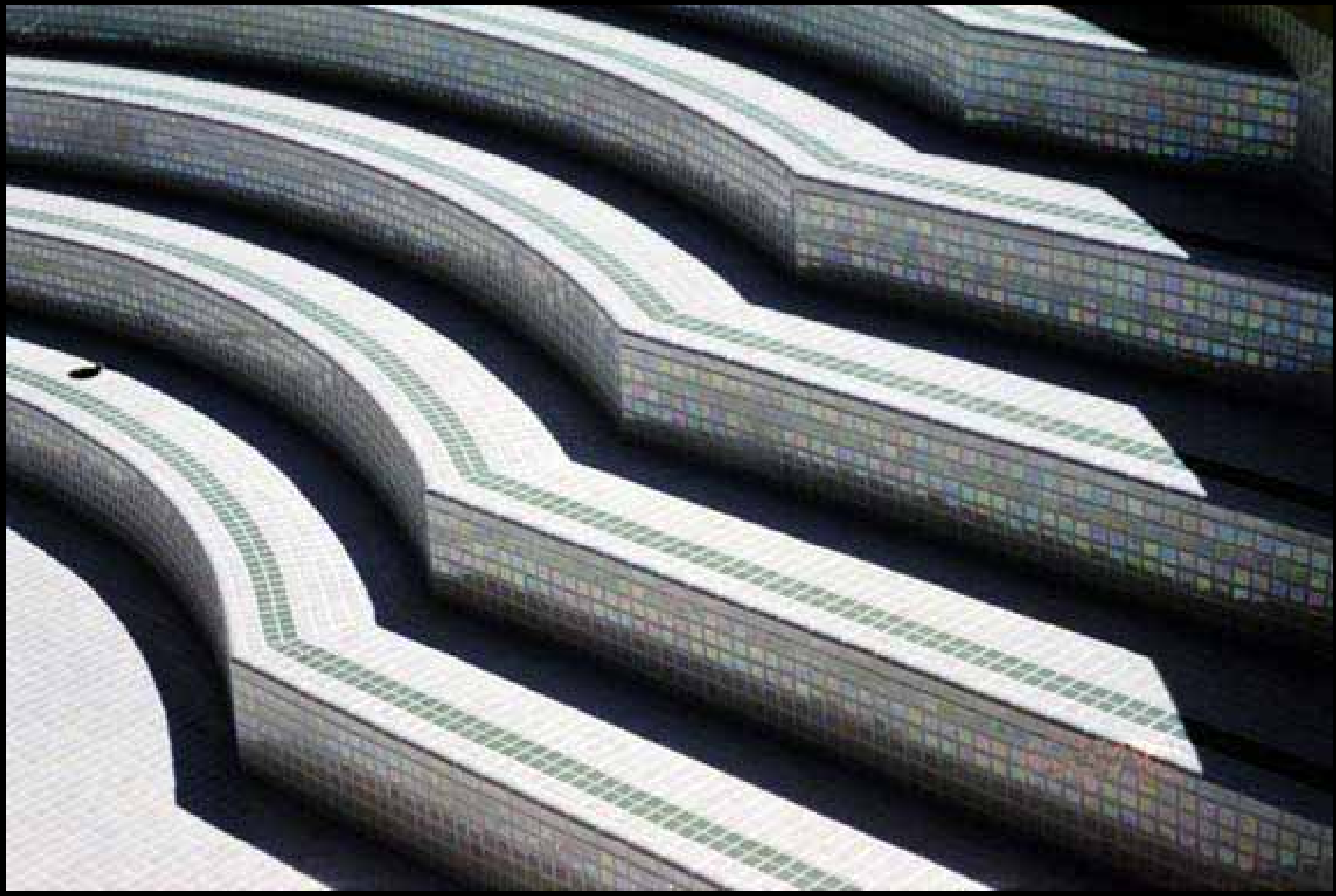
GPM ÷ 60 (sec) = GALLONS PER SECOND
GPS ÷ 7.48 (GAL PER CUBIC FT) = CU. FT / SEC
CU. FT. / SEC ÷ SQ. FT = FT/SEC

300 (gpm) ÷ 60 = 5 GPS
5 GPS ÷ 7.48 = .66 CU. FT. / SEC
.66 ÷ .33 = 2.0 FT/SEC

“High End Design”

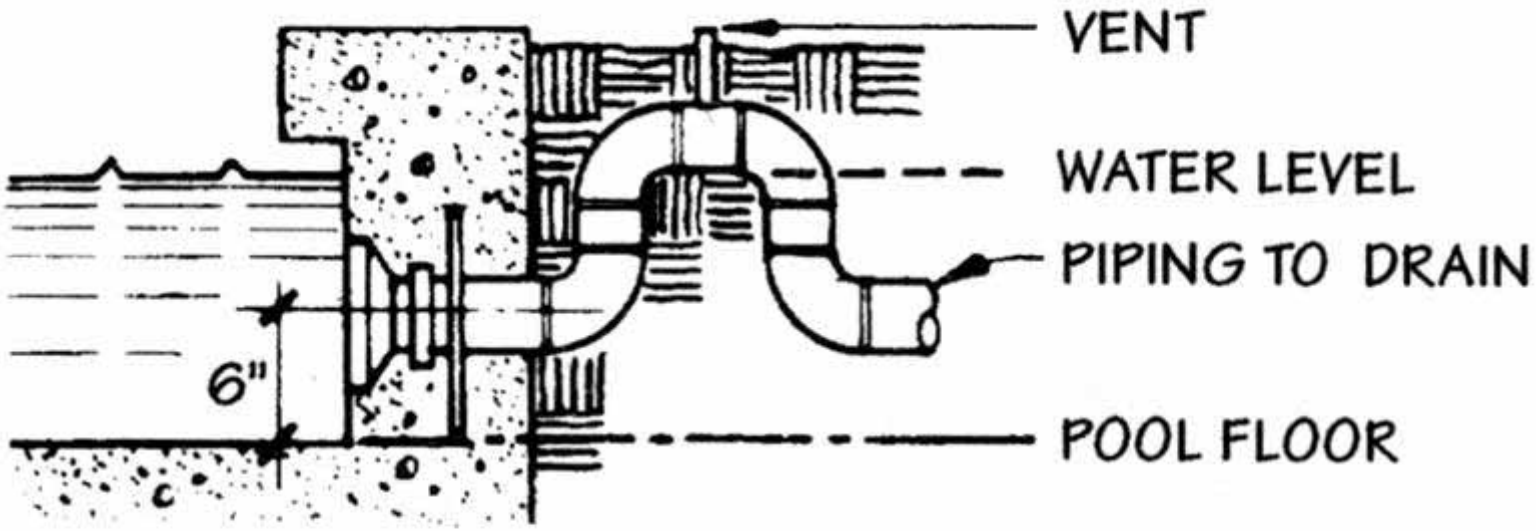
- What is it and how do I get some?
  - Observation is your best teacher
  - There are very few new ideas but many new arrangements
  - Often the design is the idea that you have to work out but sometimes it is a simple but elegant detail
  - What feels right?



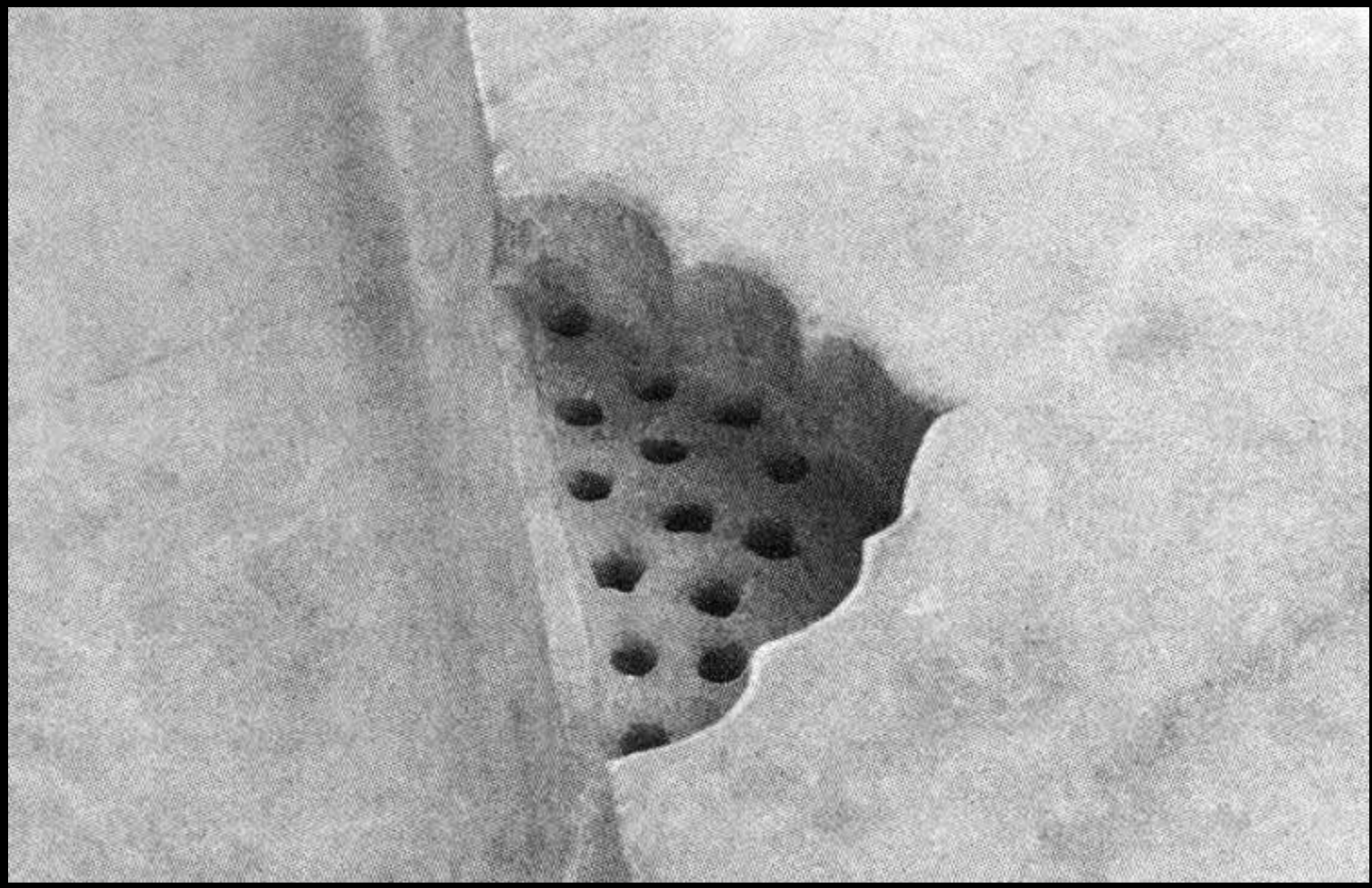


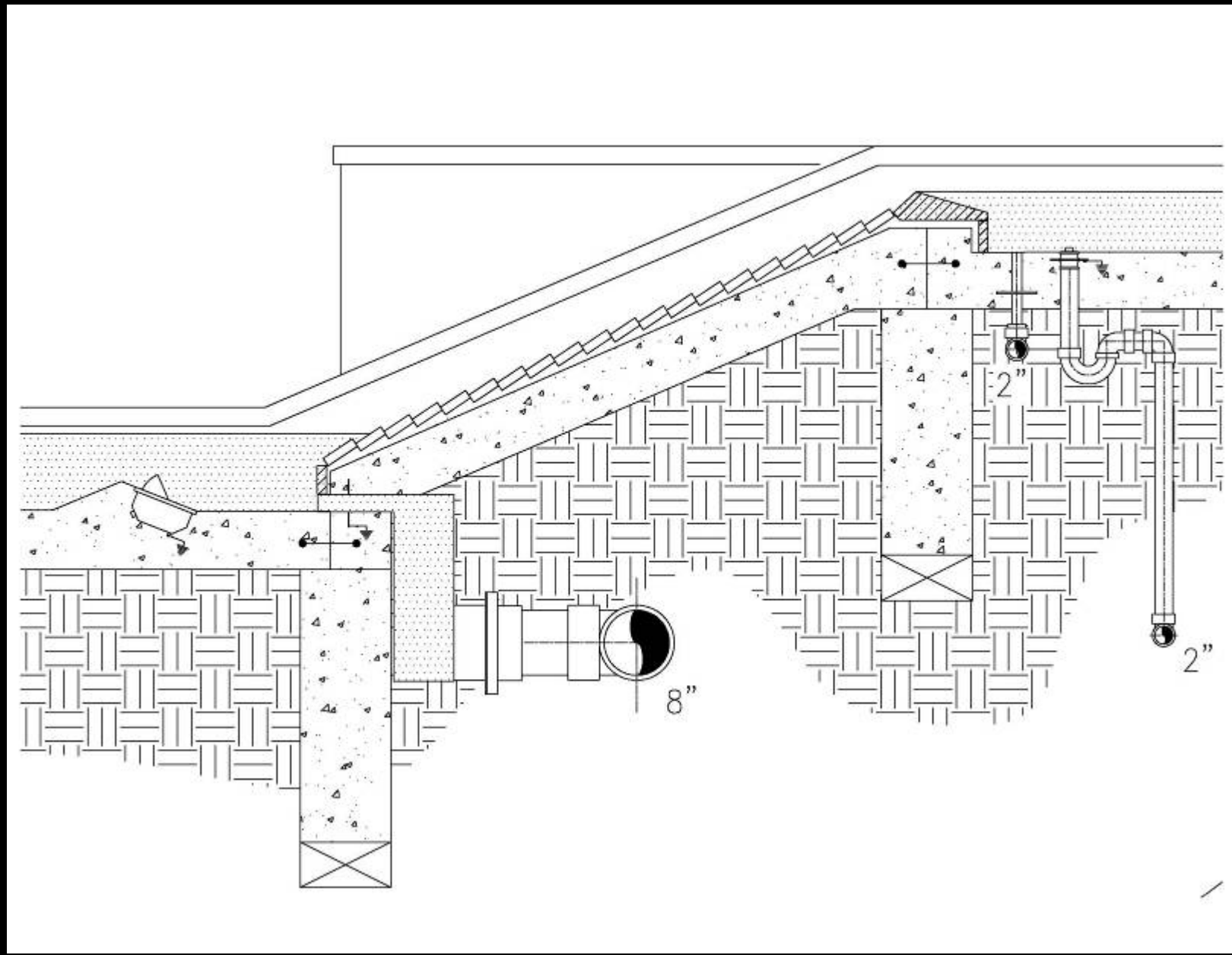

3FT


3.5 FT

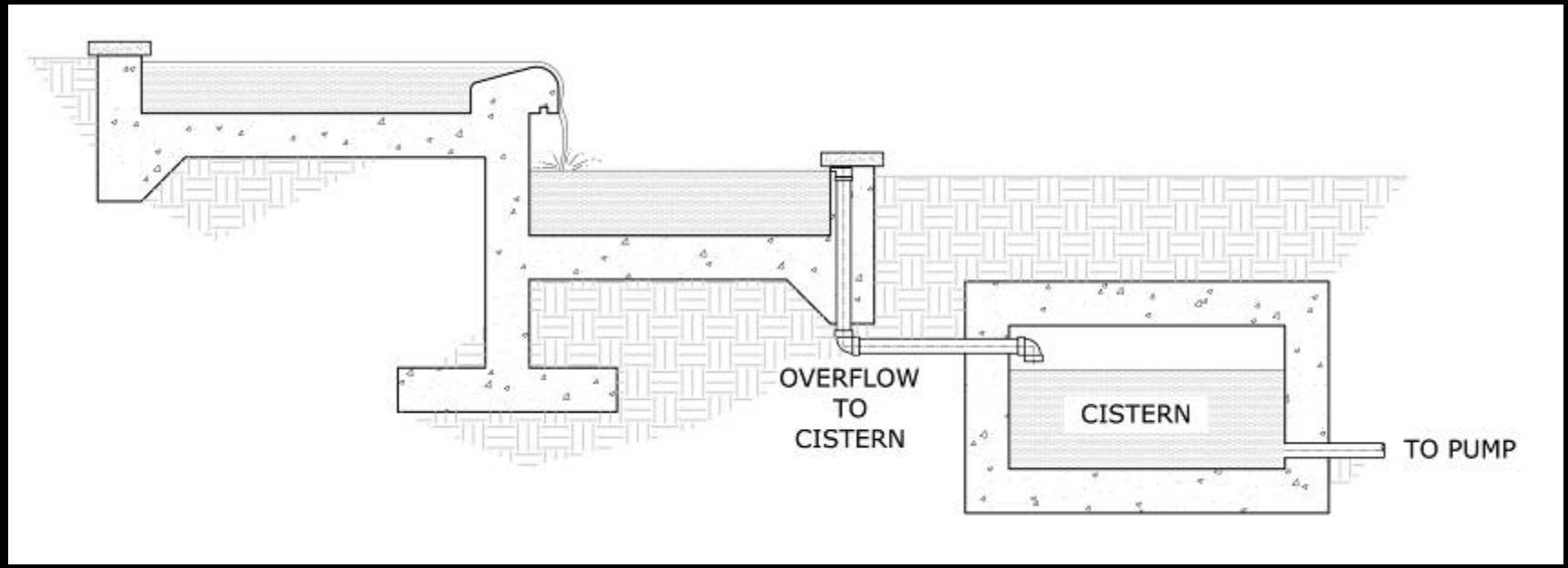


OVERFLOW FITTING




2"
2"
8"


CONSULATE GENERAL OF THE UNITED STATES OF AMERICA


OVERFLOW
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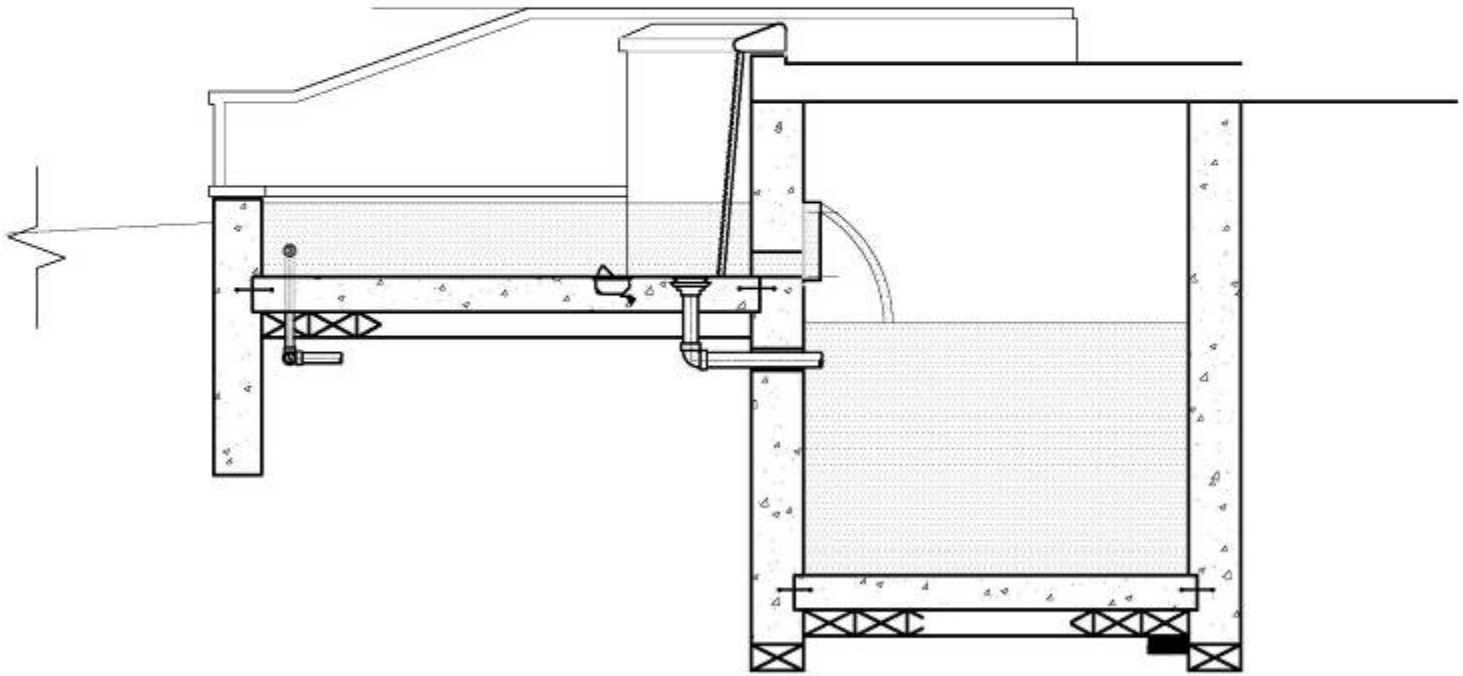
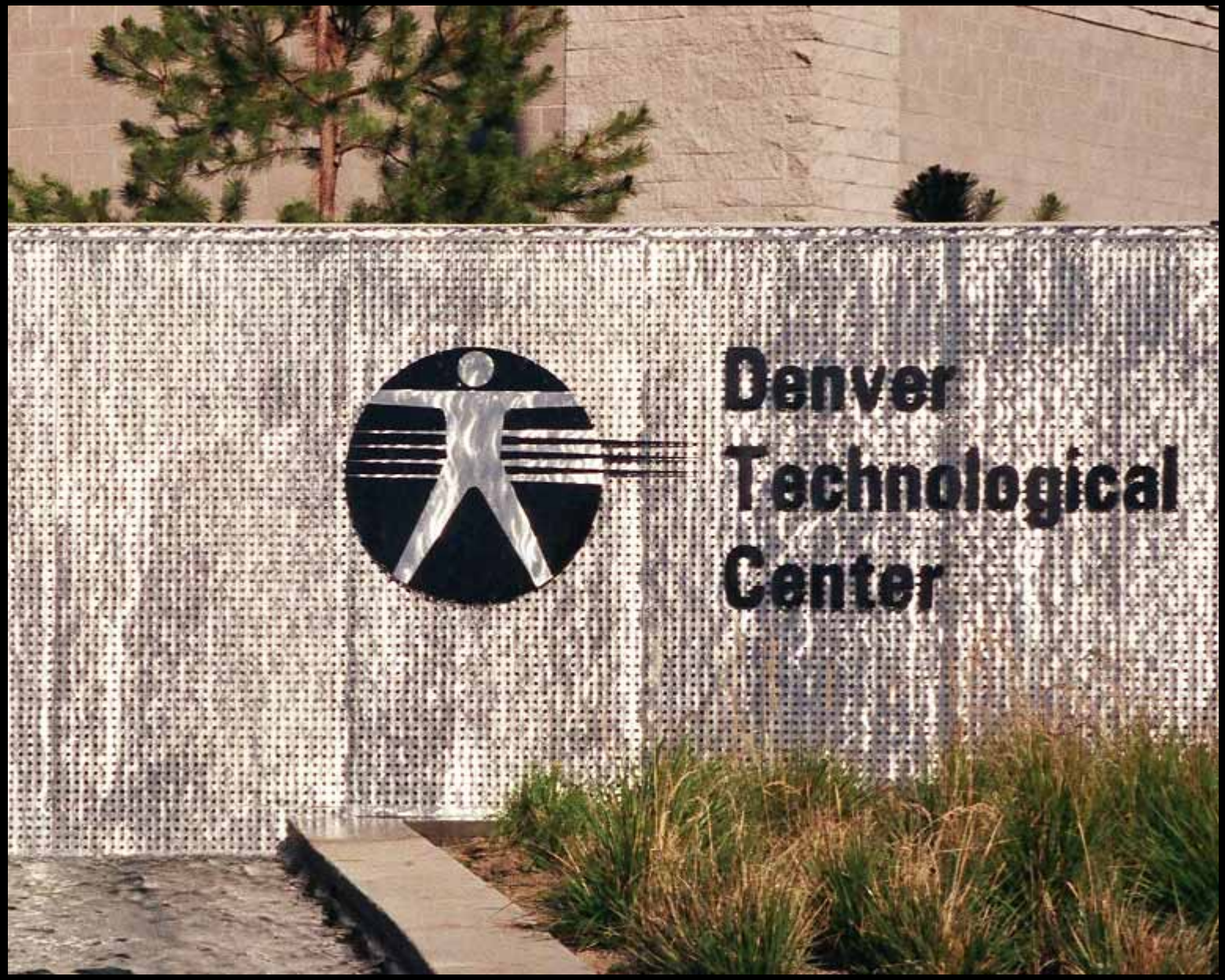


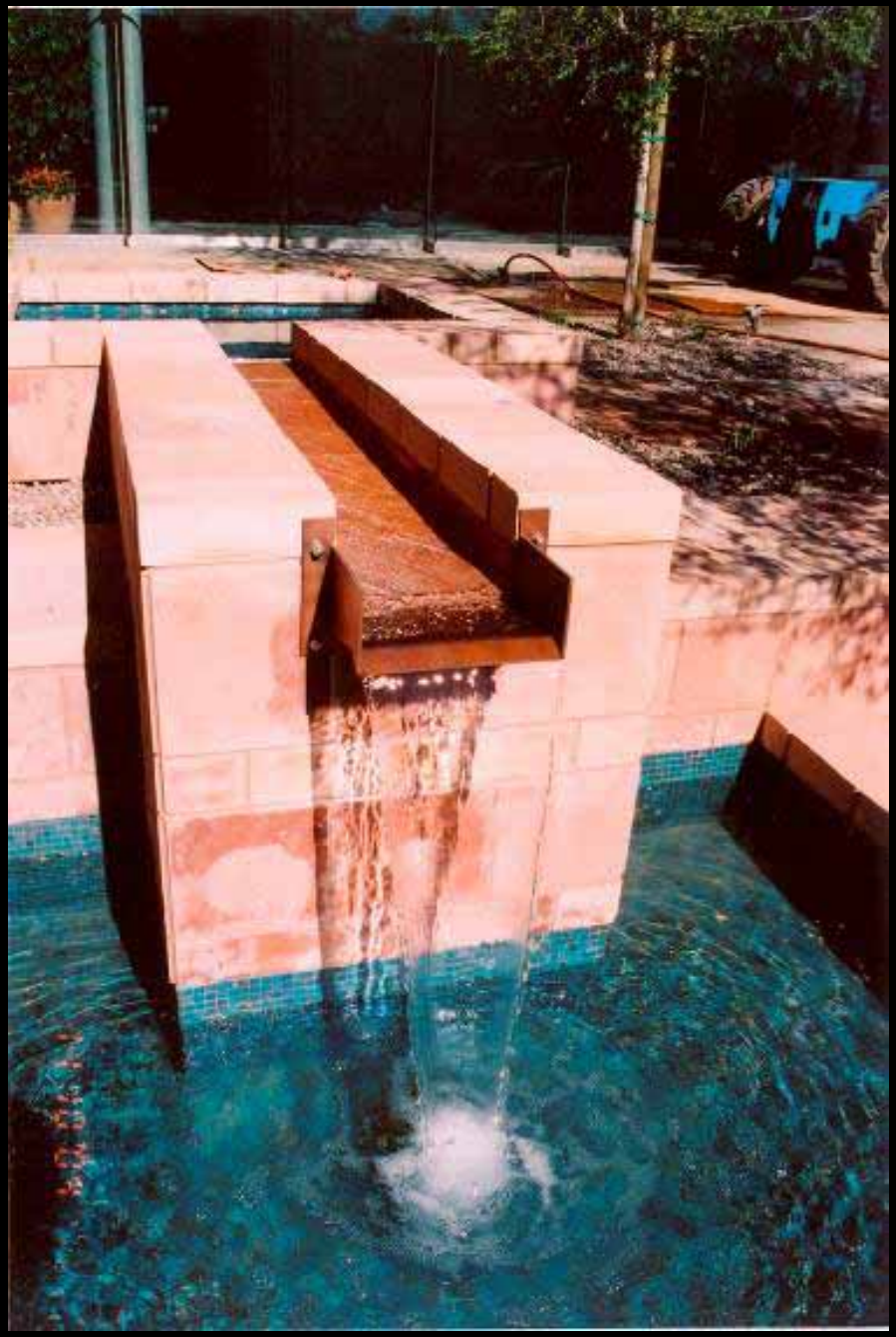

Denver
Technological
Center

Who has the ideas?

- Take the time to look through books and magazines – used book stores are great
- Look at the work of sculptors and artists for inspiration – who was Isamu Noguchi?
- Don’t be afraid to try – ask for help - test
- Scale things up and down to fit your project
- Embrace technology but don’t necessarily buy into it
- Surf the web

Interesting Web Sites

- wstudio.com/
- www.flow-forms.com/
- www.fountainkinetics.com/index.html
- www.inexan.com/
- www.williampye.com/
- www.pariswater.com/fontaines/fontaine.htm
- www.thais.it/citta_italiane/roma/fontane/fontane.htm
- www.fountainsinthecity.com/
- www.seattlesolstice.com/
- www.rockartist.org/index.html
- www.architecturalstone.net/index.html
- www.rhodes.org/
- www.gardenvisit.com/
- www.profloinc.com



Trompe L’oeil

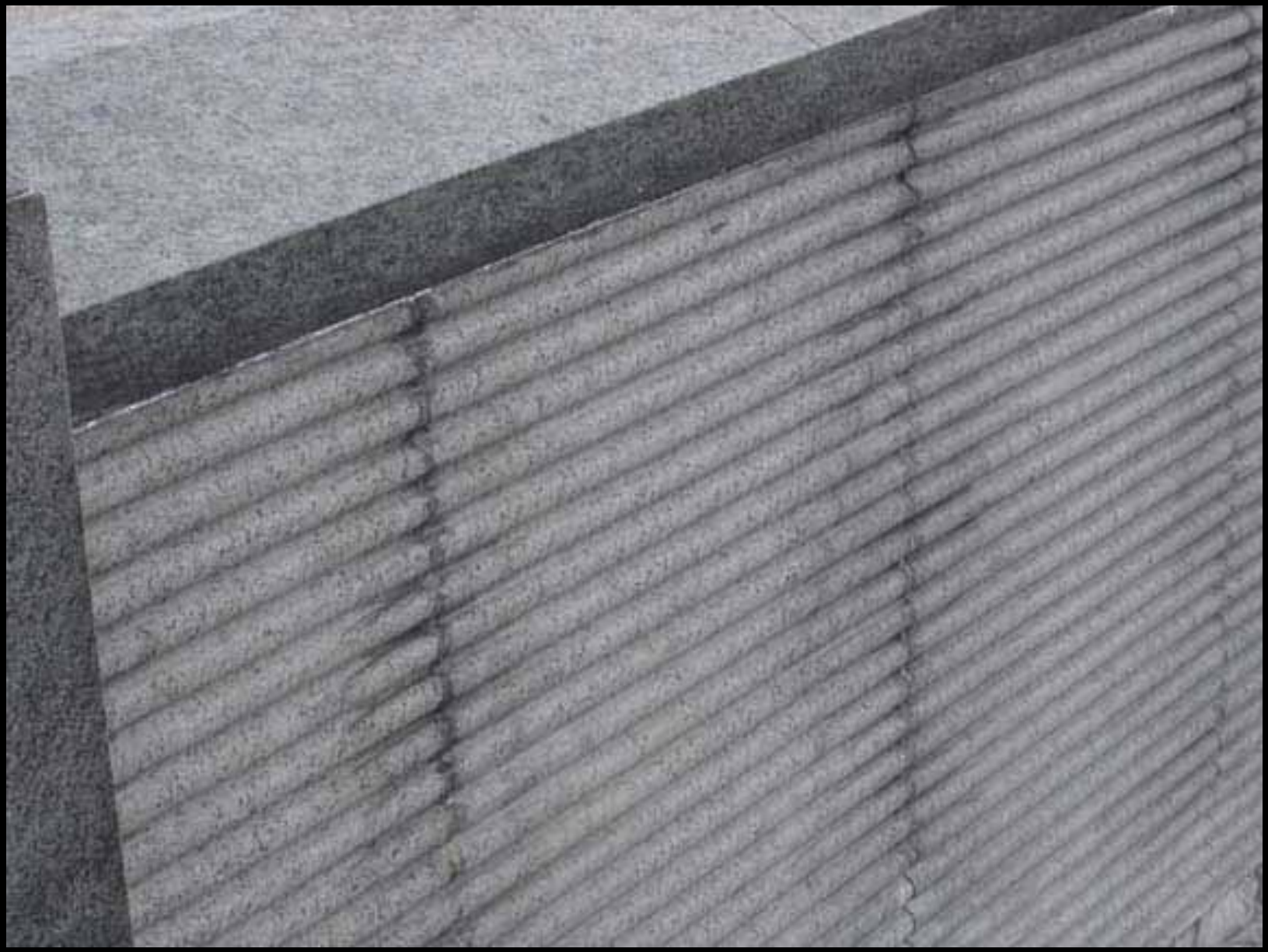
- **Tromp loy – to fool the eye**

Observation

- What does your library look like?
- Teach yourself to look at the surroundings of a project you like to find out how all of the elements contribute to the whole success.
- Carry a camera
- If you pay attention, you will learn something new every day

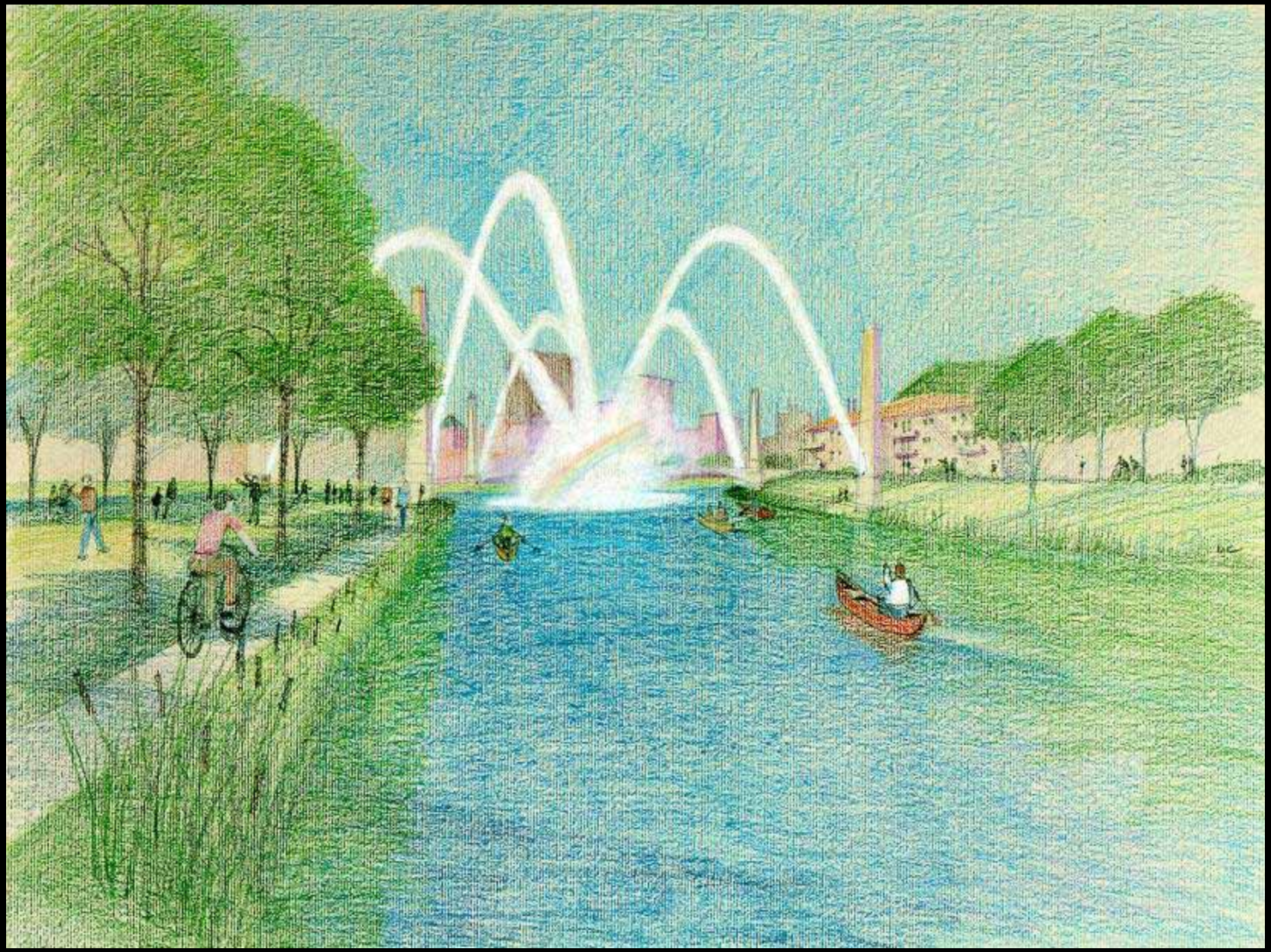
Mock it up

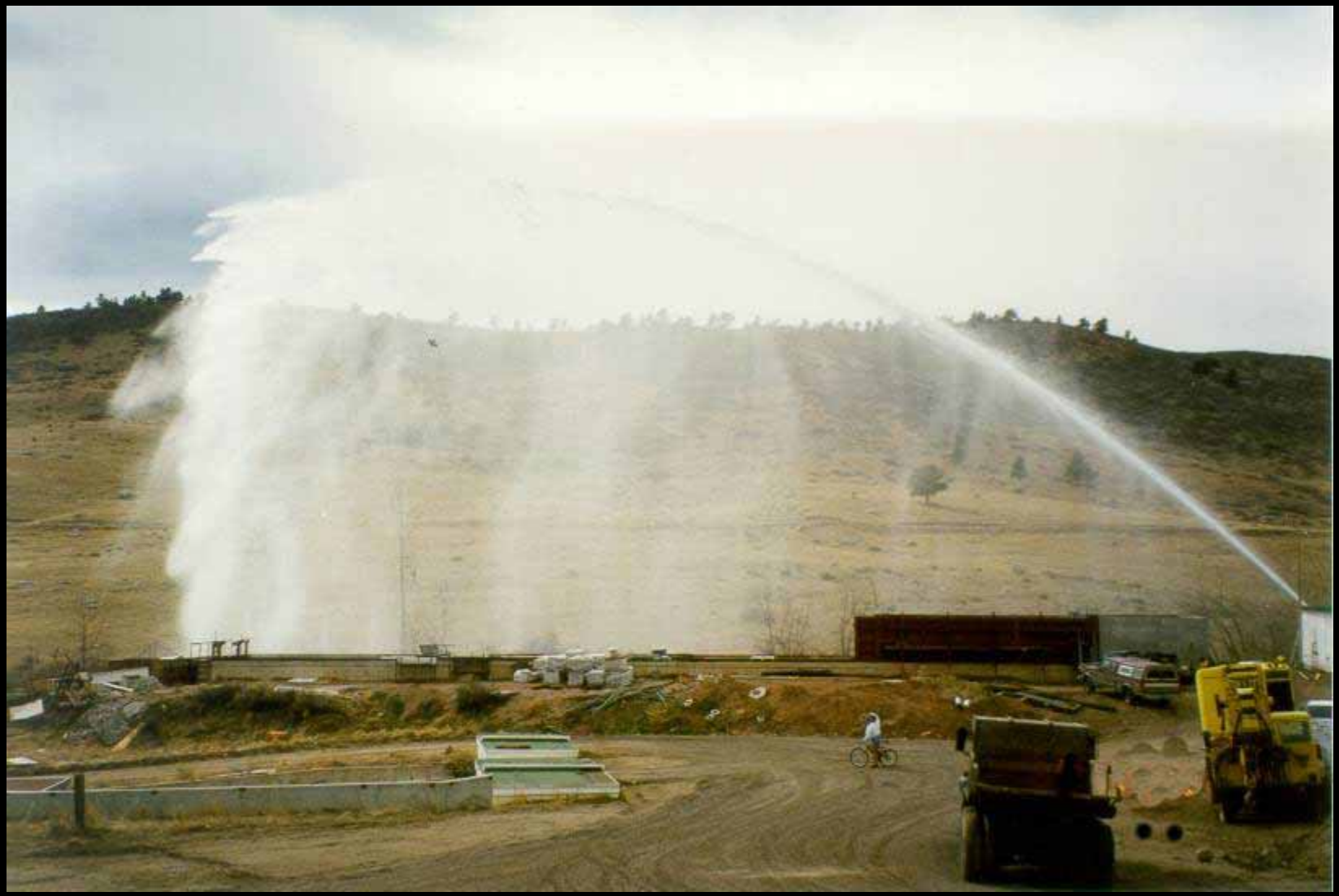
- **Test the effect – don’t guess**



Where do you get help?

- Landscape Architects / Architects
- Fountain Consultants
- Fountain Manufacturers
- Artists – in all mediums
- Peers and contractors
- Manufacturer's representatives
- Universities – students and professors

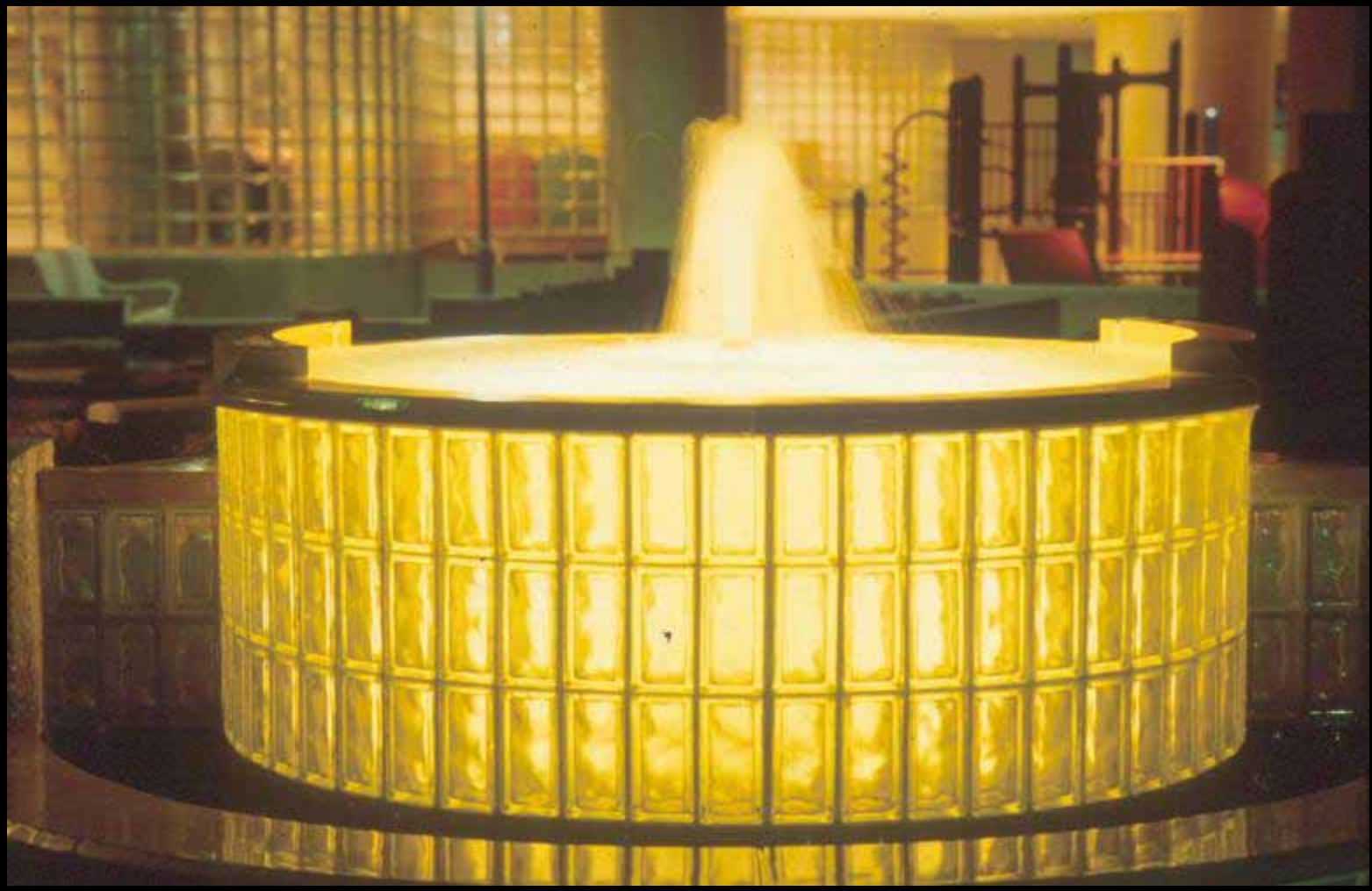


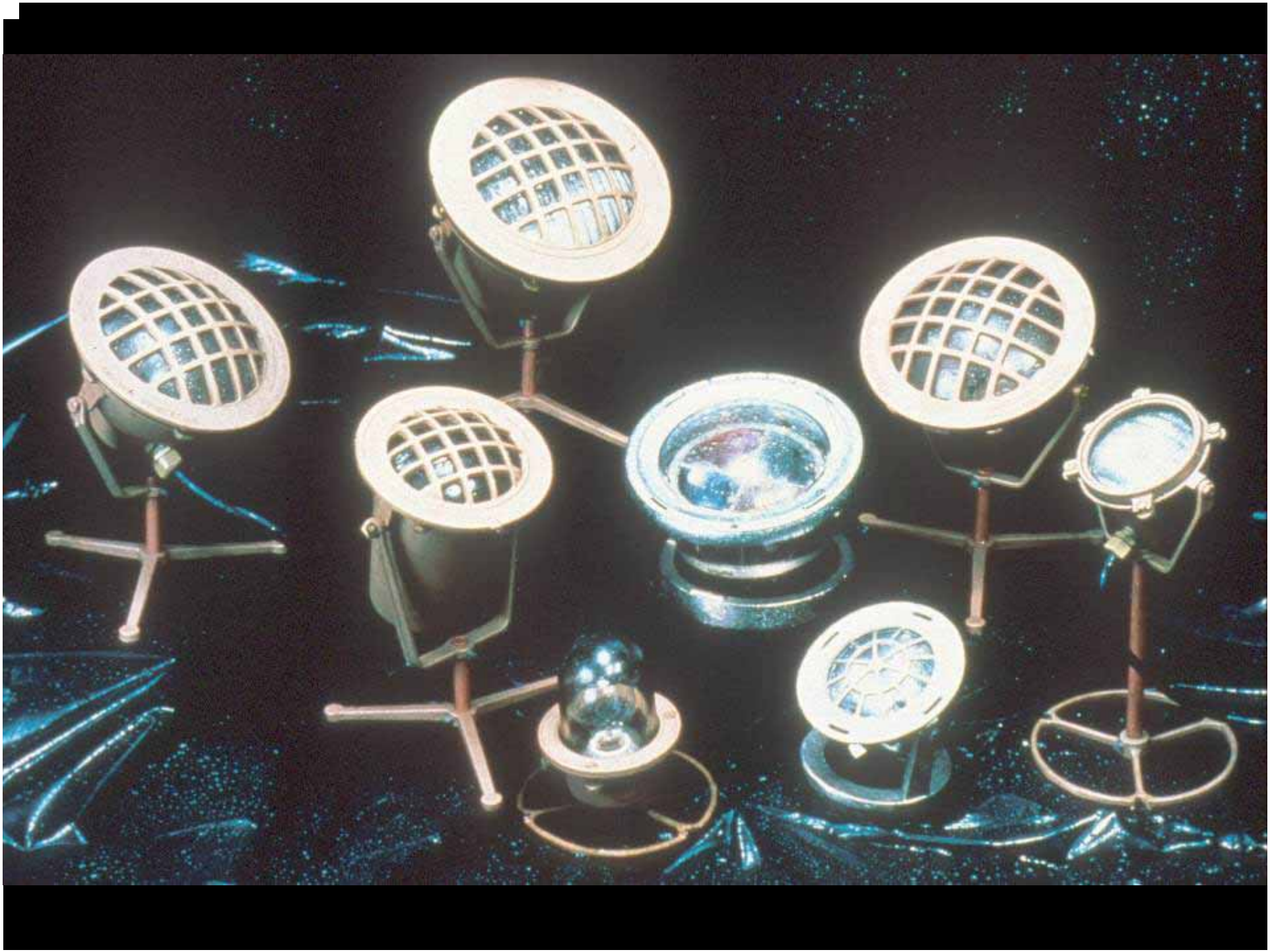



6:30


OBA OBA
IN A TRIP TO
AEROLINEAS
ARGENTINAS
SOUTH AMERICA
SOUTH AMERICA

LIGHTING





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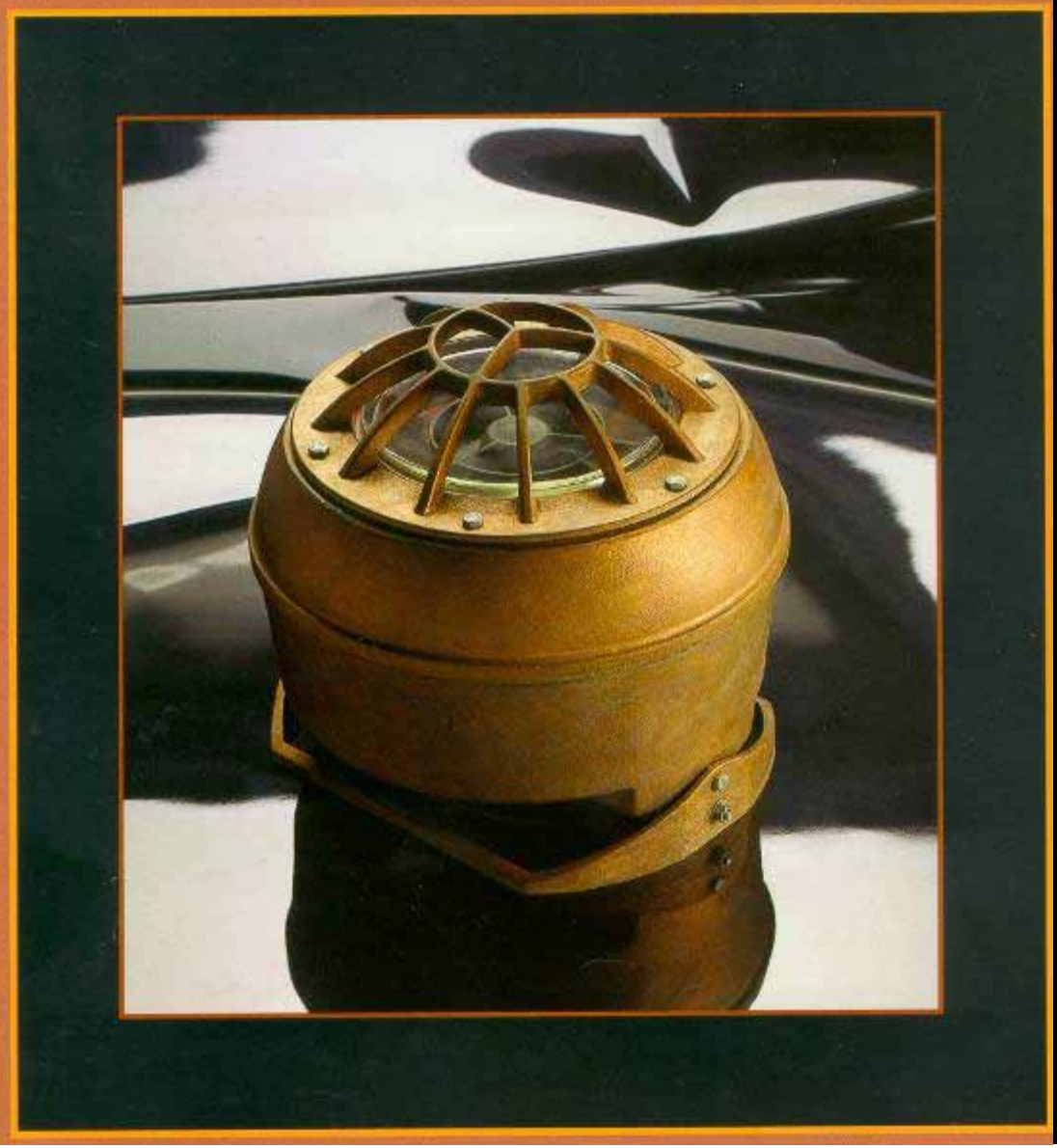

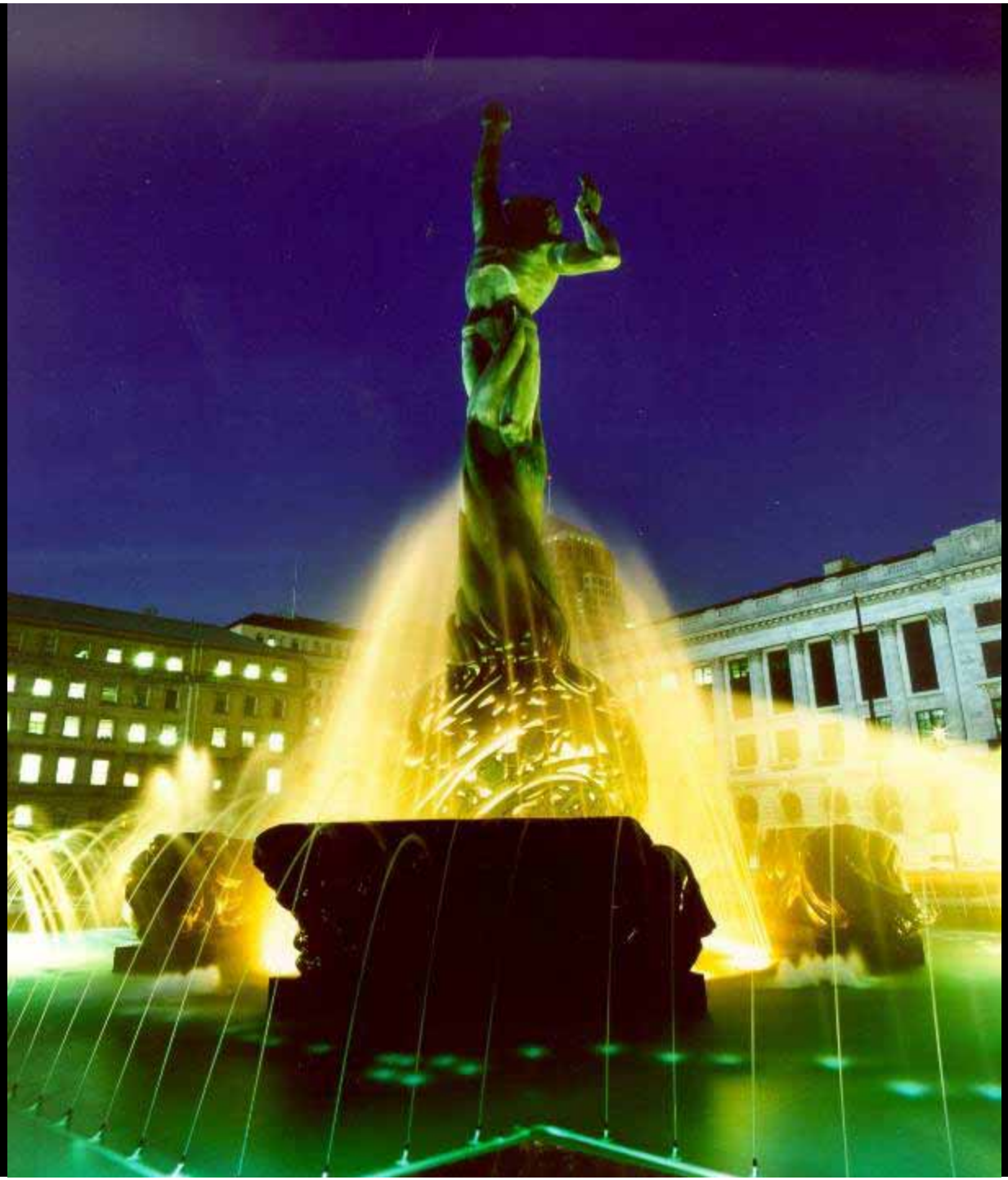

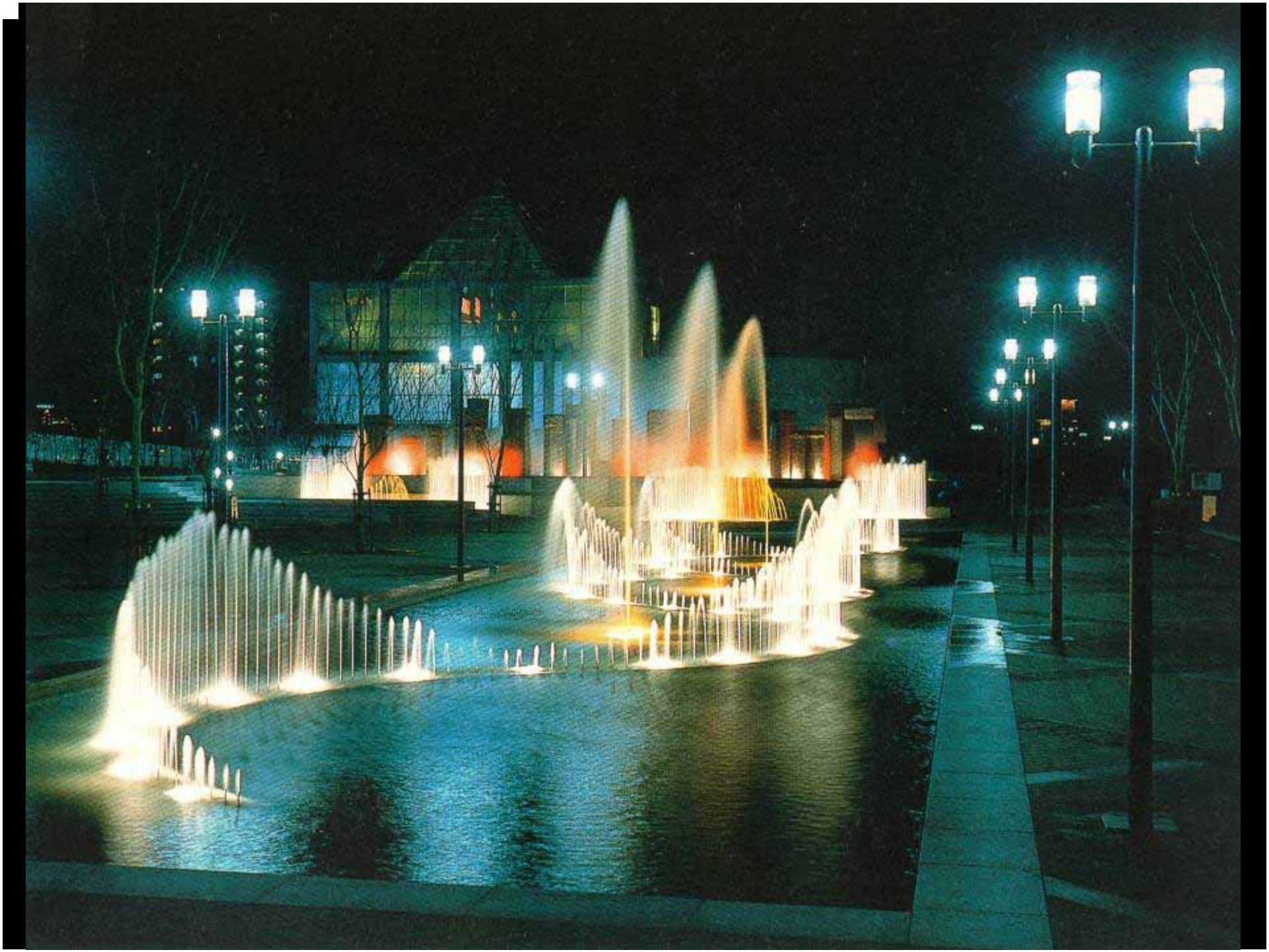

THE END