Dry Suit Diving

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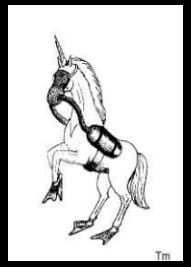
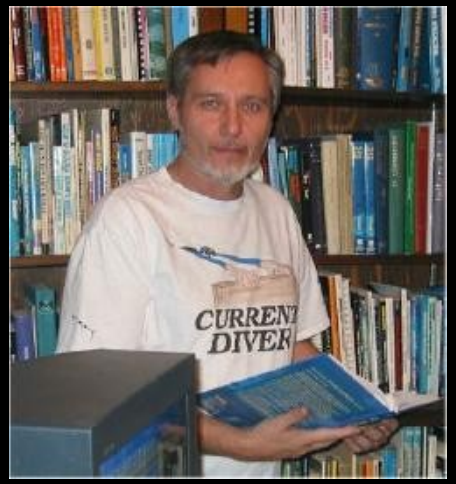
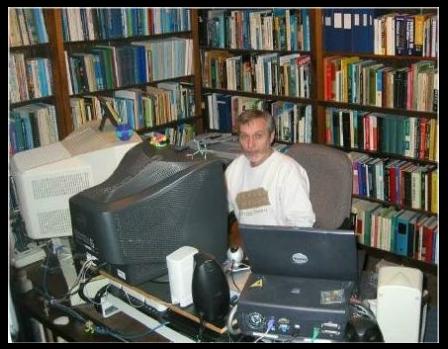
Your Instructor

U of MI Diving Safety Coordinator
AAUS sanctioned Diving Safety Officer
Internationally rated 3 - star instructor (CMAS)
National Master Scuba Instructor (President's Council)
> 100 Diving Certifications
> 200 Diving Publications
> 1,200,000 visitors to "Diving Myths & Realities" web site
Library: one of the best resources in North America
Scuba Diver since 1977
Scuba Instructor since 1980
DAN Instructor since 1991
EAN_x Instructor since 1992
Ph.D. Biochemistry







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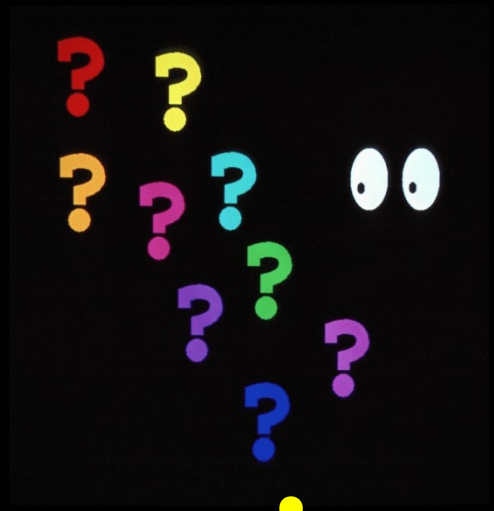

Lecture is a Democracy!

You control speed with your questions

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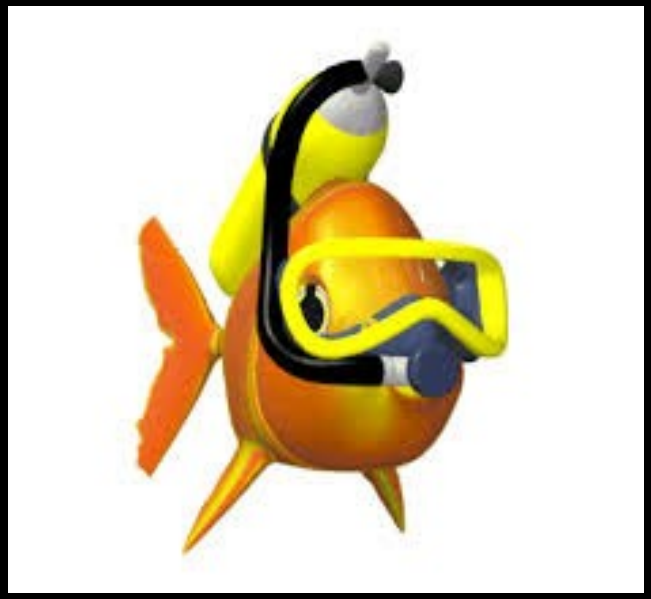
Water-work is Dictatorship!

Do as instructed or leave the water



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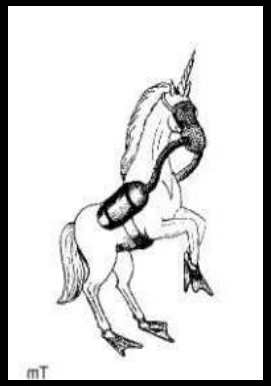
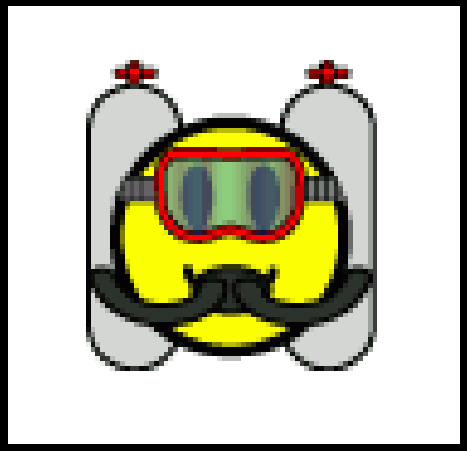
Knowledgeable, Physically Fit Divers

Gospel

According to "Harris"

Have More Fun!





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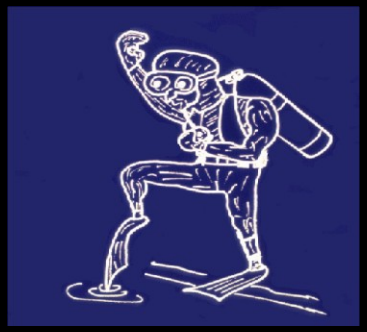
Three Great Truths:



Diving Is Fun

Being Cold Is NOT Fun

Wet & cold divers subsidize those diving warm & dry

Wet-suited divers:
Cold, On deck

Dry-suited divers:
Enjoying third dive

EFFICIENCY AND RELIABILITY

	Wet Suit			Dry Suit		
Temp	Dive Number			Dive Number		
	1st	2nd	3rd	1st	2nd	3rd
70°F	100%	100%	100%	100%	100%	100%
60°F	100%	90%	80%	100%	100%	100%
50°F	80%	70%	50%	100%	100%	100%
40°F	50%	25%	*	100%	85%	75%
32°F	*	*	*	100%	75%	55%

*Not Recommended
Table Based On 30 Minute Dives At Depth Of 50 Feet

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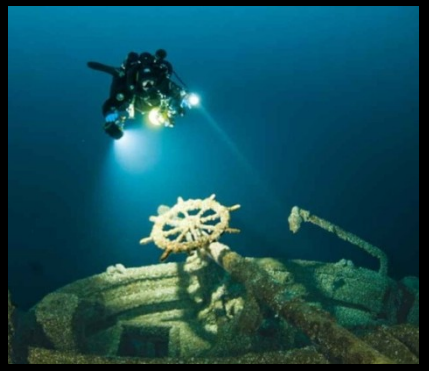
Must Understand Heat Loss to Protect From the Cold



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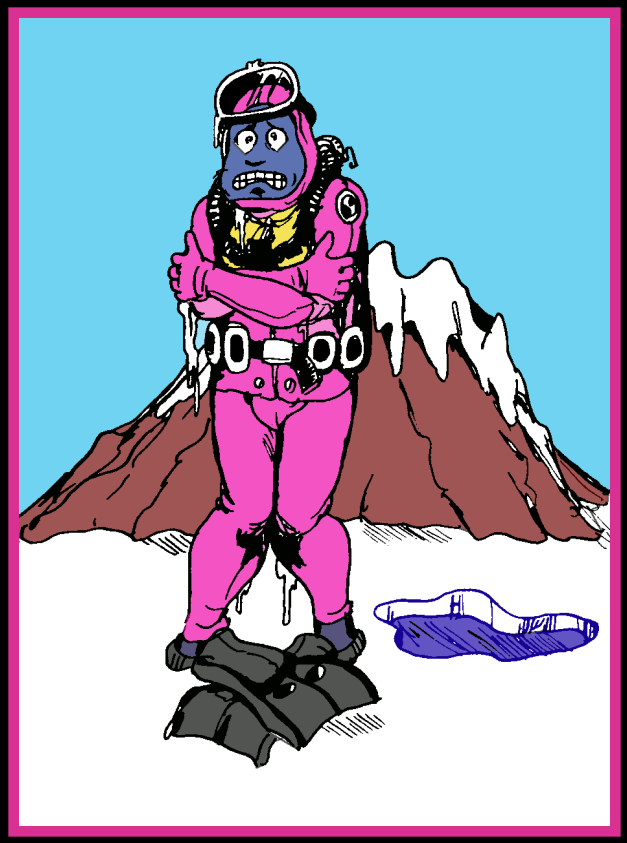
Ignoring (or Not Understanding) Heat Loss



It is always the "not known" that poses the greatest risk

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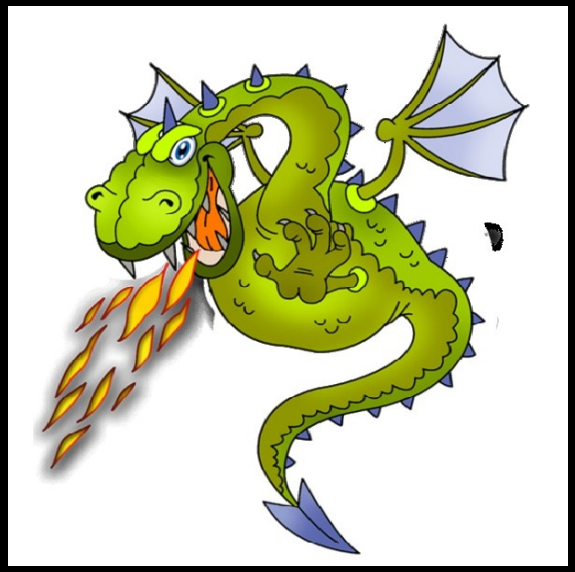
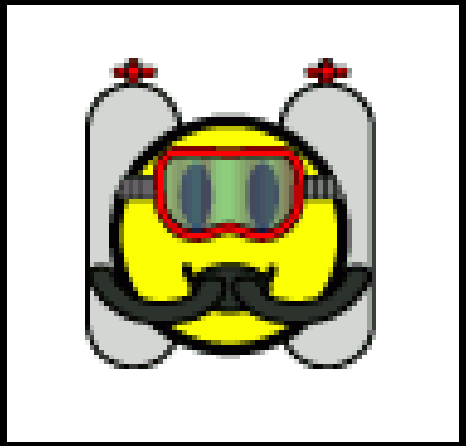


Heat



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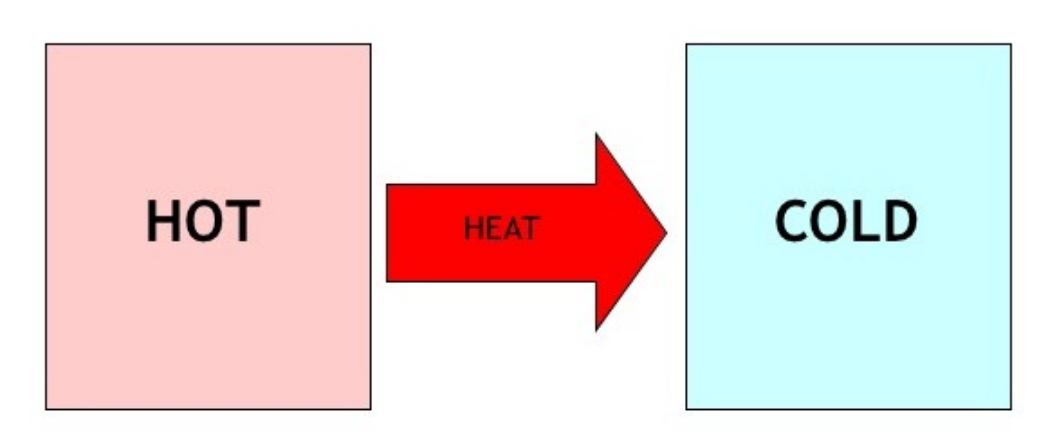
Heat is a Fluid



Flows from hotter to colder
until
temperatures are equal

Cannot stop movement
Protection comes from slowing process

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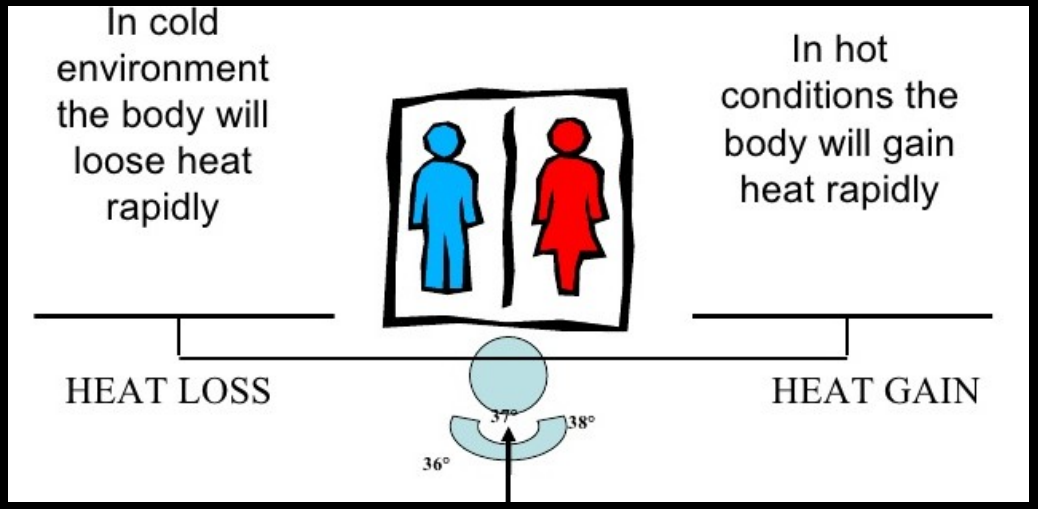
Thermal Balance

Heat Out:

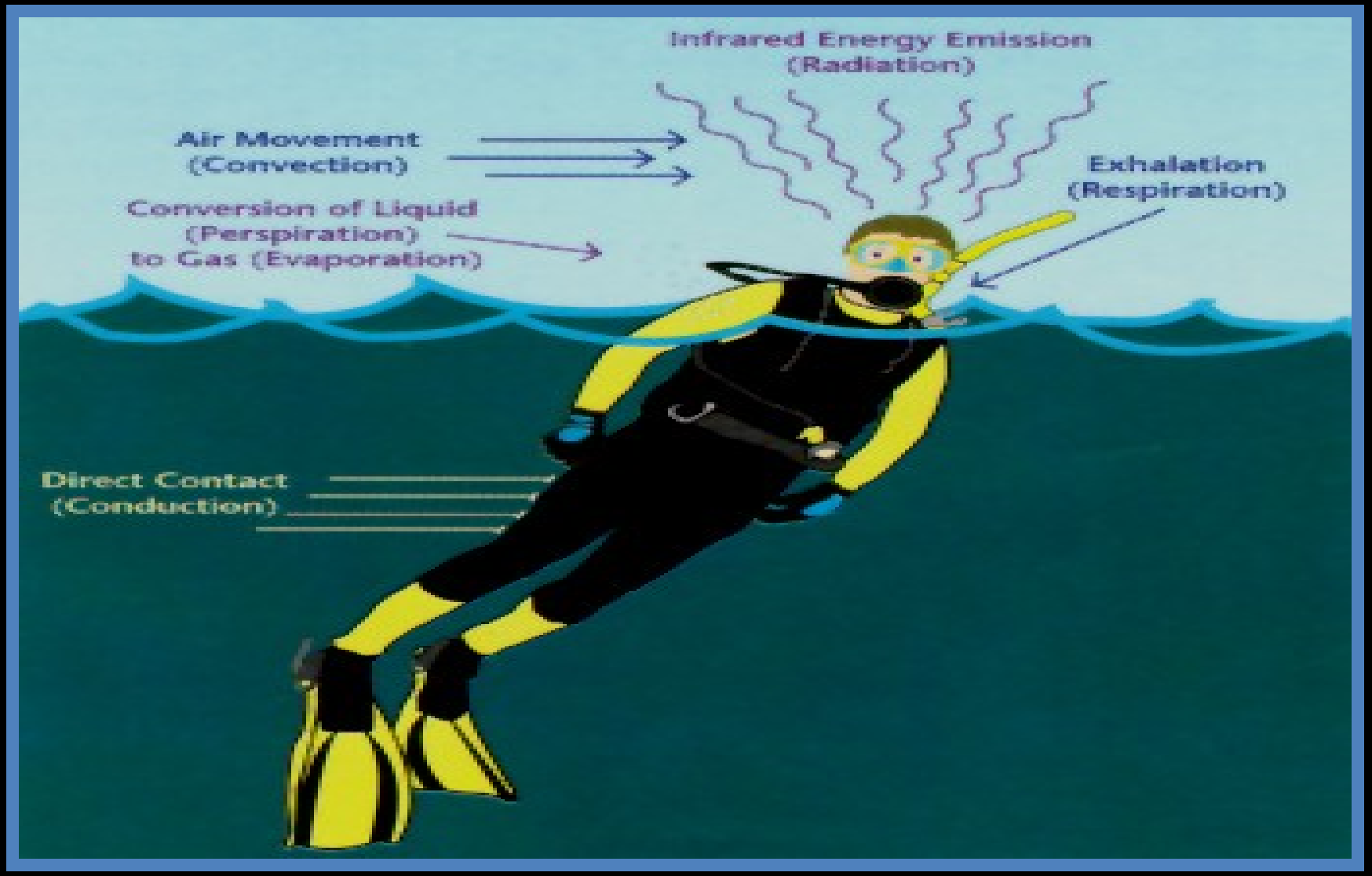
- **Environment**
  - Conduction
  - Convection
  - Radiation
- **Cooling**
  - Respiration
  - Perspiration
  - Excretion
- **Disease**



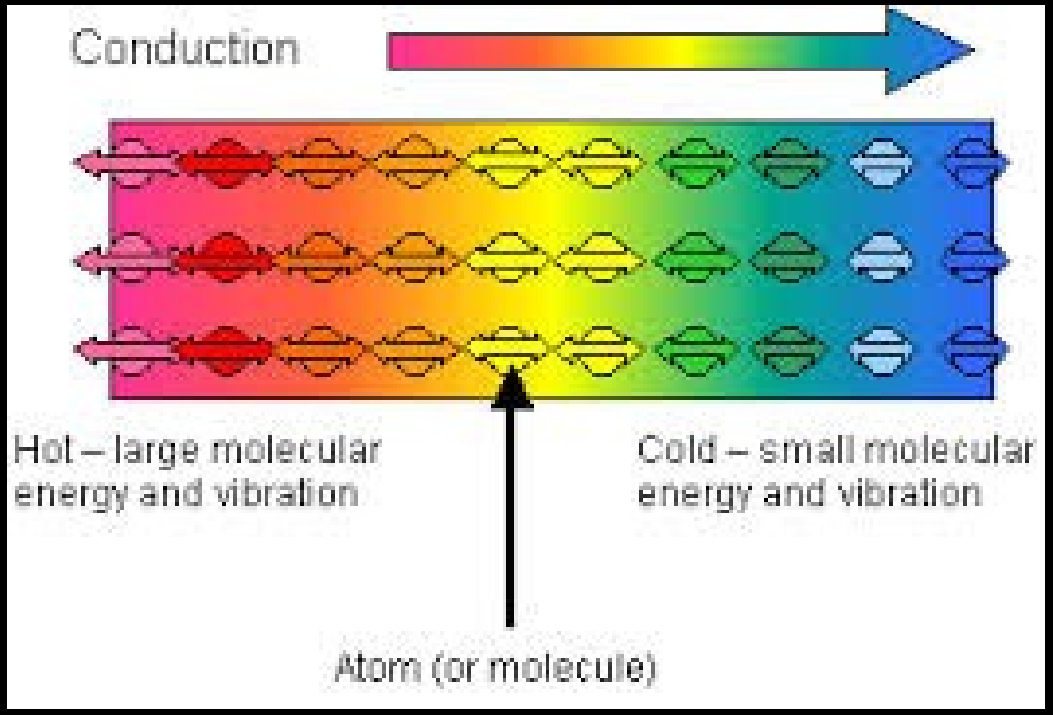
Heat In:

- **Metabolism**
- **Muscle Movement**
- **Environment**
  - Conduction
  - Radiation

In-Water Heat Loss



Thermal Loss: Conduction



Water removes heat ~ 25 x faster than dry, still air at same temperature

Direct transfer of energy at the molecular level

Major source of in-water heat loss

Heat loss to water

Heat loss warming breathing gas

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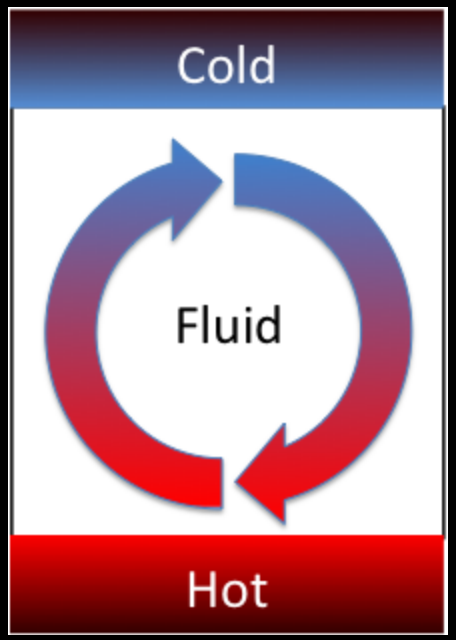
Thermal Loss: Convection



Moving liquid removes heat

Continual process

Wet suits restrict convective flow

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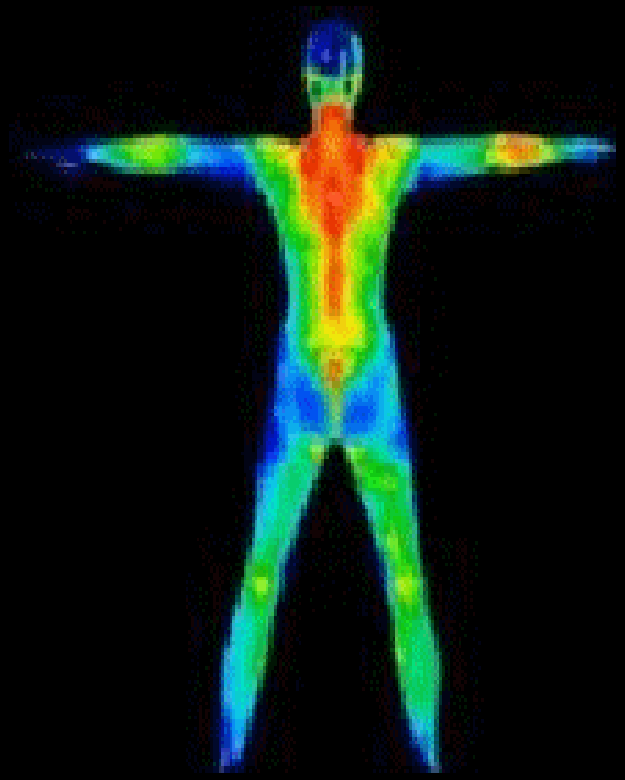
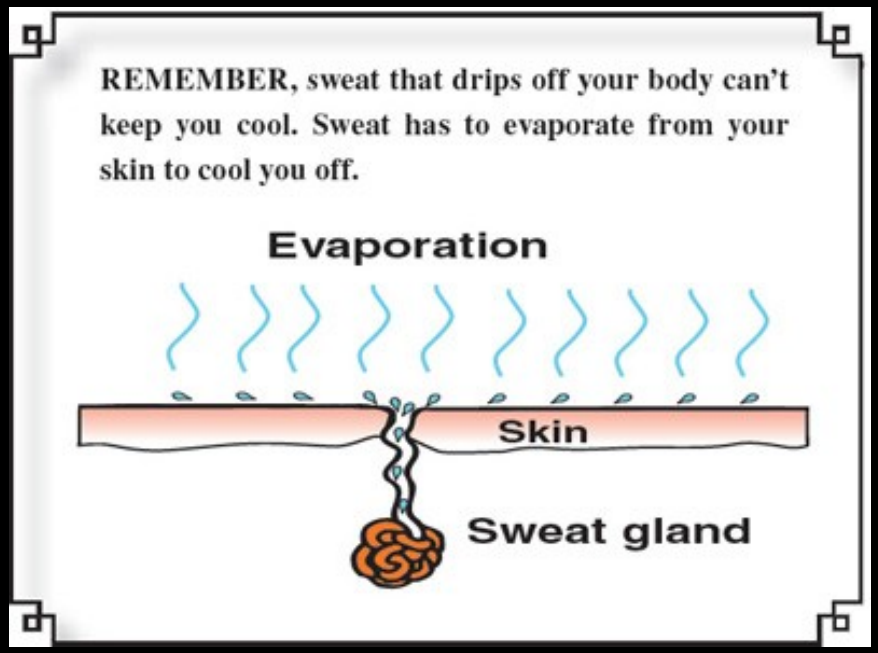
Thermal Loss: Radiation



Emission of infra red radiation

Minor problem in the water

Thermal Loss: Evaporation / Respiration

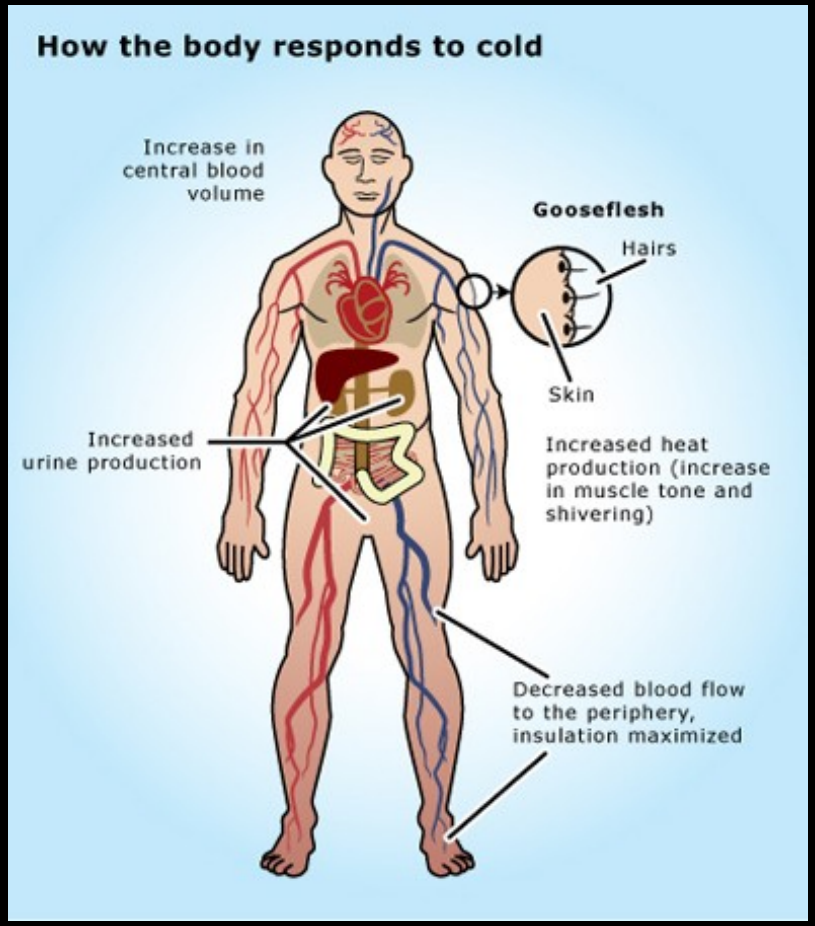


Change of state:
Liquid → gas
Requires energy

9.72 kcal / mole

Pre-dive sweating
Insensible perspiration
Humidifying dry breathing gas

Humans are Tropical Critters
Better coping with heat than cold



Hot	Cold
Vasodilation Arterioles dilate (enlarge) so more blood enters skin capillaries and heat is lost.	**Vasoconstriction** Arterioles get smaller to reduce blood going to skin: keeping core warm.
Sweating Sudorific glands secrete sweat which removes heat when water changes state.	**Shivering** Rapid contraction and relaxing of skeletal muscles. Heat produced by respiration.
Pilorelaxation This means the hairs flatten.	**Piloerection** Hairs on skin stand up.
Stretching Out By opening up, the body was a larger surface area.	**Curling Up** Making yourself smaller so smaller surface area.

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Simplistic View of a Biochemist:

Heat = Life

Cold Robs Heat

No Heat = No Life

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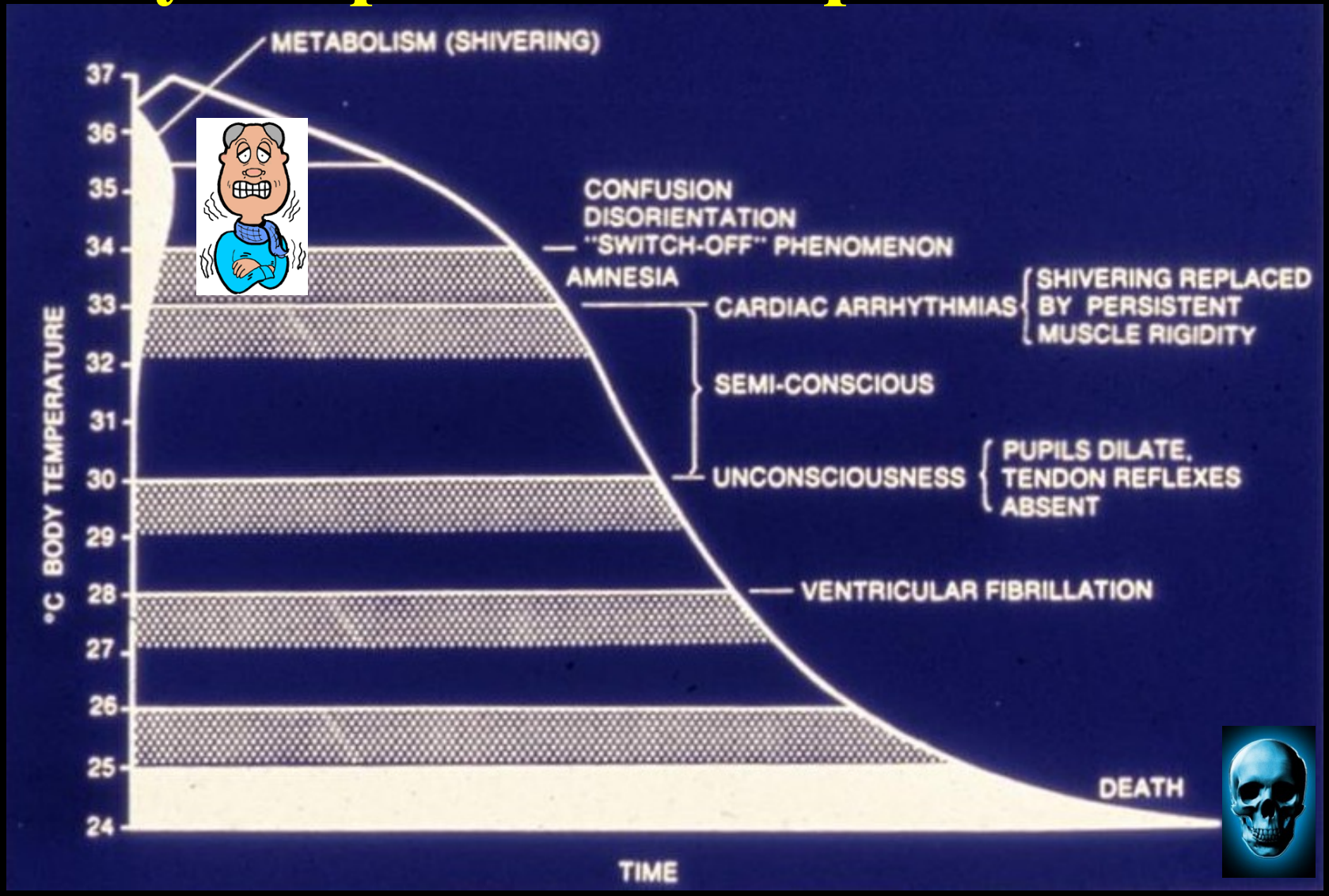
Body Response to Temperature Loss



First Shiver: Abort the dive!

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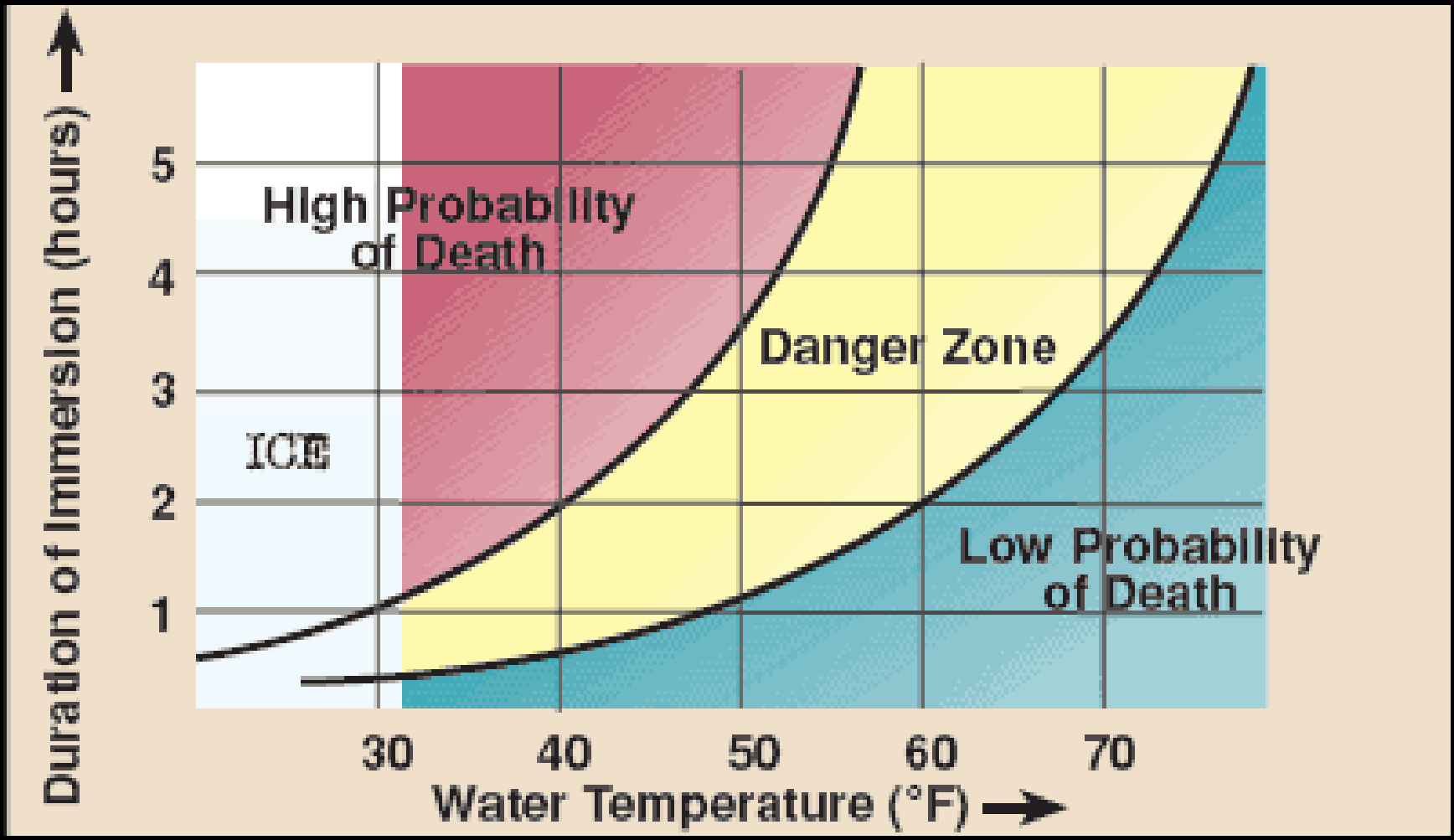
Estimated Unprotected In-Water Survival Time



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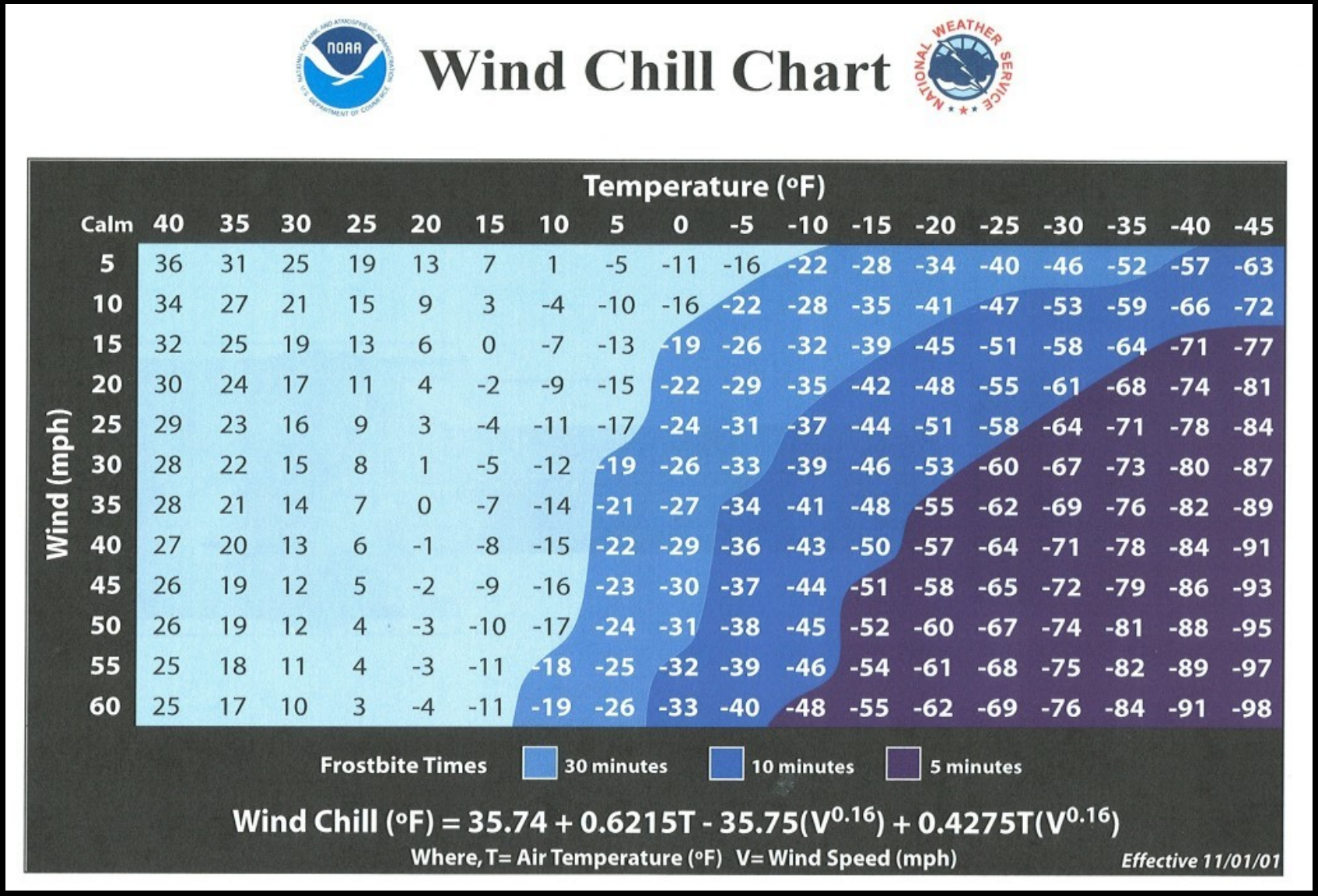
Wind Chill Can Lead to Substantial Heat Loss



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Cold

Cold:

Major physiological stressor

Major obstacle to diving participation

Major obstacle to limited bottom time

This is a course in NOT being cold

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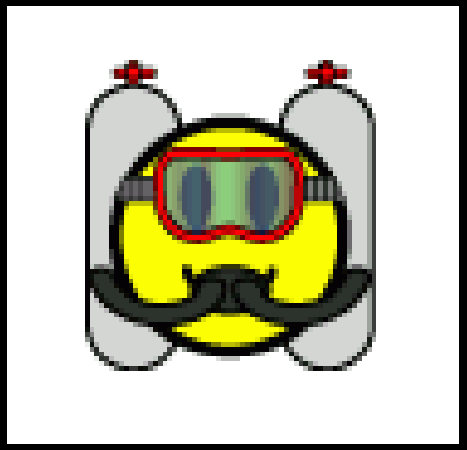
Not Being Cold



Commercial Divers Often Use Hot Water Suits

Surface supplied:

- Tether
- Breathing mix
- Communications
- Hot water

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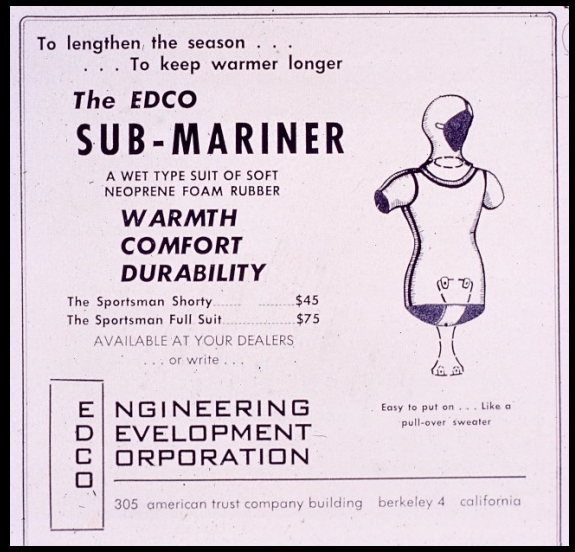
Historic Thermal Protection Schemes



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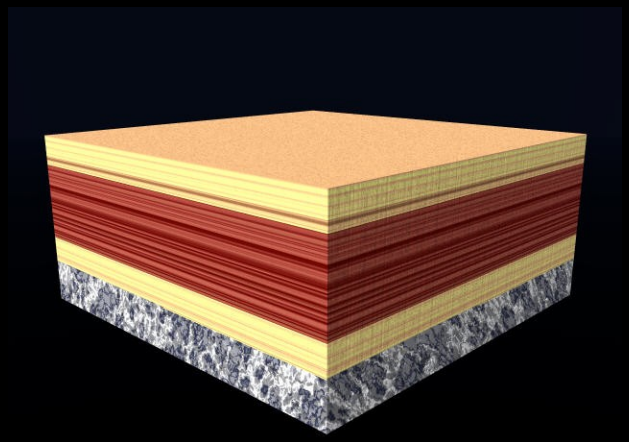
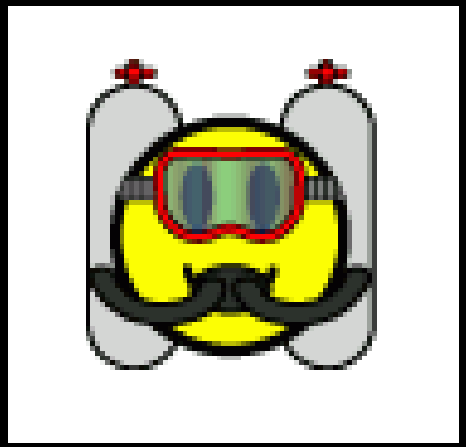


The Layer Concept



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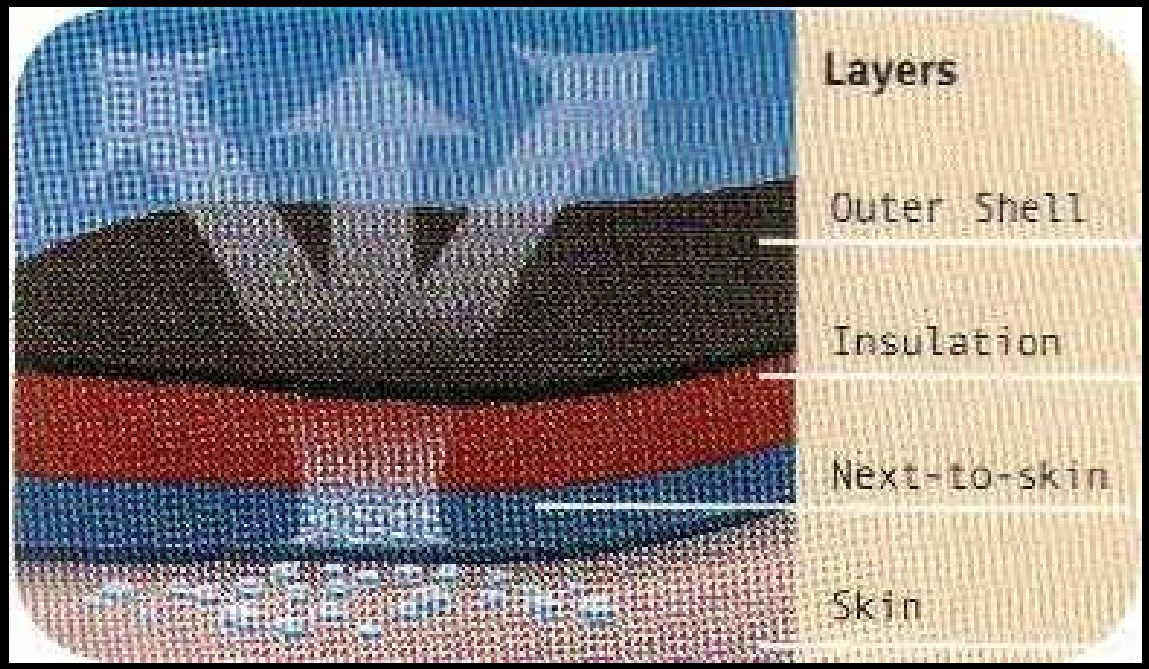
Three Layers of Thermal Protection



Layers varied depending on

Environmental conditions

Workload

Personal Comfort

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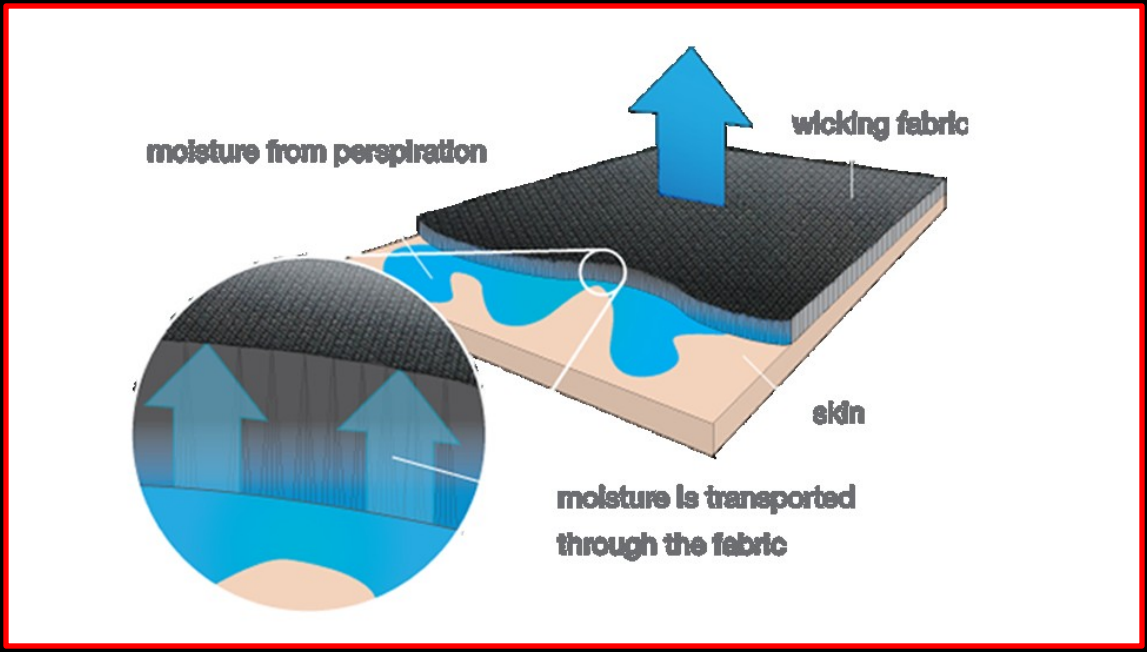
First Layer: Next to Skin

Purpose: Keep Skin Dry



Hydrophobic microfiber wicks water away from skin

Dry skin loses heat much slower than moist skin

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First Layer: Next to Skin

Polypropylene
Capilene
Dry Base
Xerotherm
Dry Max (Socks)

Must be synthetic material (all natural fibers absorb water)
Different weights available (dependent on temperatures/workload)

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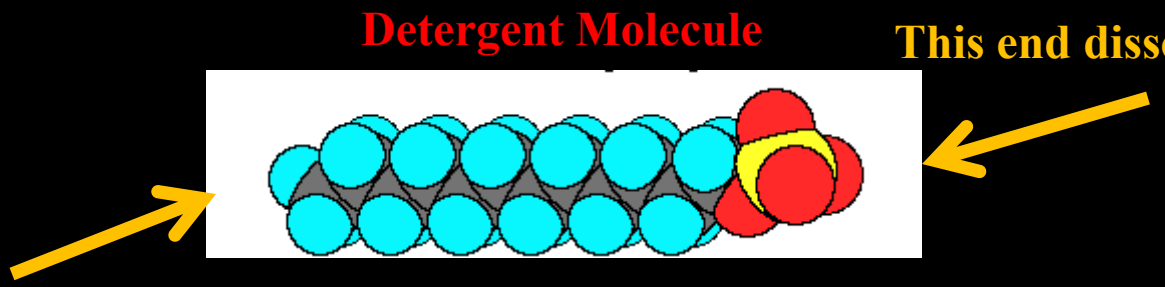
Hydrophobic Materials Soon Acquire a Foul Body Smell
(Body oils stick to hydrophobic material and turn rancid)

Wash with breathable fabric detergent, (tiny amount of detergent) in cold water then smell the garment



If detergent odor present:
(This "stuck" detergent can absorb water / lessen insulation)
Wash with only cold water until detergent smell is gone

On trips, best to have multiple sets of first layer garment

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Second Layer: Insulation

Primary resistance to heat loss

Fabric is matrix to hold trapped gas (the insulator)

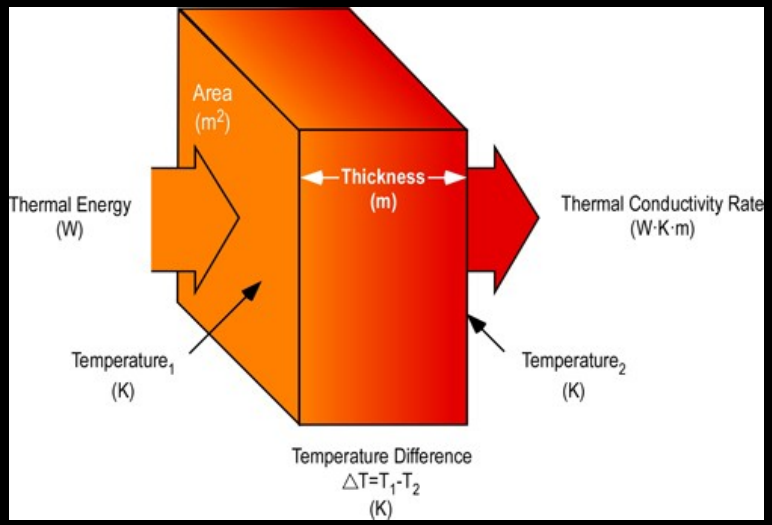
$$\text{Insulation value} = \frac{\Delta T \; A \; t}{C}$$

ΔT : temperature difference

A : cross-sectional area

t: time

C: Thermal Conductivity



Heat loss depends on:

- Temperature difference across barrier
- Thickness & area of insulation
- Thermal resistance / conductivity of insulator
- Time

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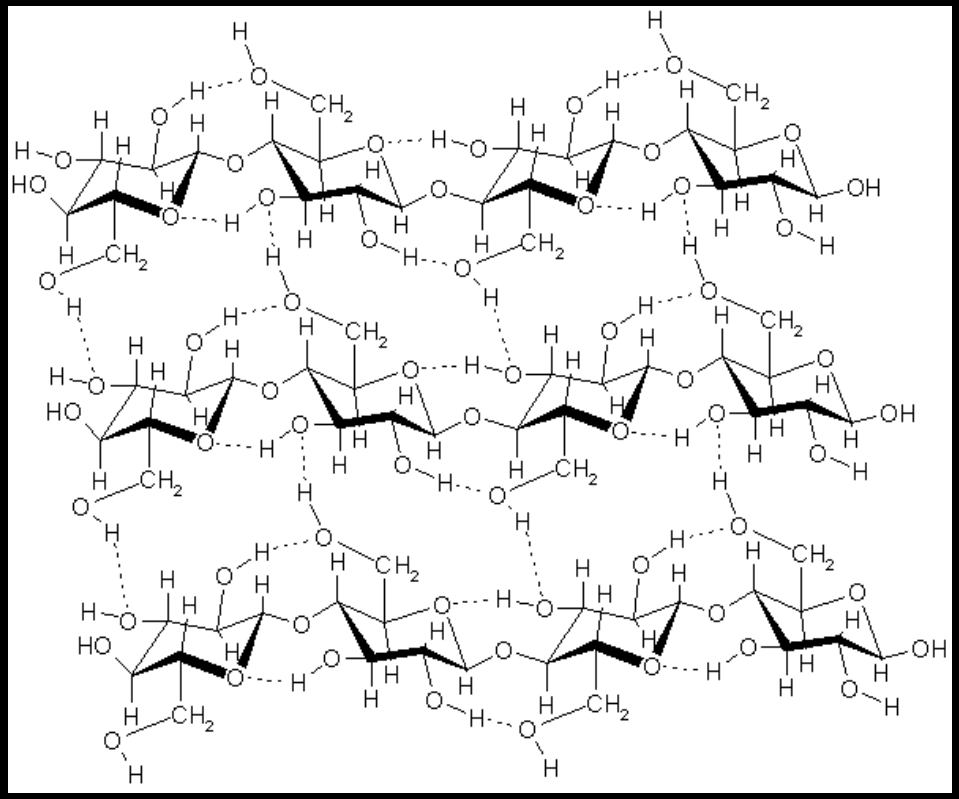
Second Layer: Insulation

Cotton (cellulose) is a No! No!



Cotton is a poly-sugar

Every –OH can grab water

All natural fibers absorb water

Water decreases insulation

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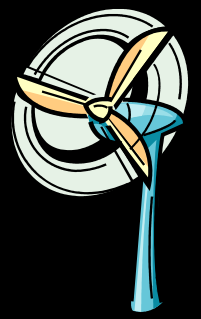
Cellulose (Cotton)

Ability to hold water makes cotton a "great' summer fabric

- perspiration "grabbed" by cotton fibers
- water evaporates
- evaporation takes heat
- result is a cooling effect



Ability to hold water makes cotton an undesirable in-water fabric

- evaporative cooling promotes heat loss & hypothermia
- water removes heat ~25 x faster than dry still air of same temperature
- Fogery : > 50% wilderness deaths a result of wearing cotton jeans
- Yosemite Rangers: wearing cotton in winter → "death-seeking behavior"

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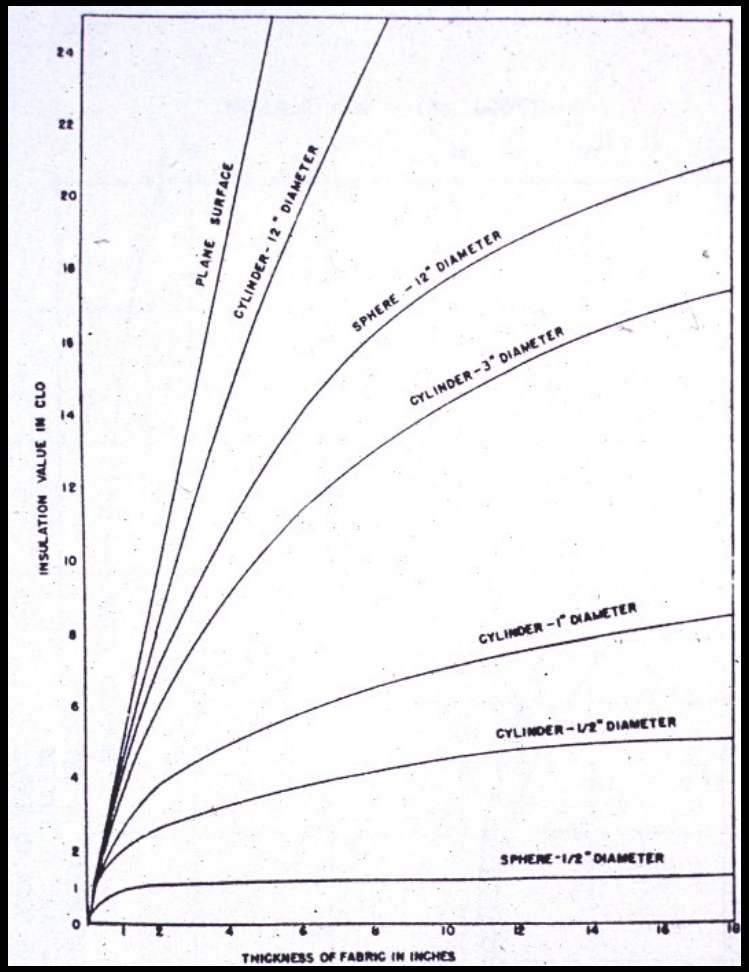
Second Layer: Insulation

Shape of insulator affects heat loss



Best Resistance : planar surface (at right angles to heat flow)

In general:

Planar > cylindrical > spherical

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Second Layer: “Wooly Bears”

Wool or synthetic “pile”

Very comfortable next to skin

Warm, as long as dry

Loses insulation rapidly when wet

Loses insulation when compressed

Decent insulation at reasonable price

Least expensive protection

Pile may clog valves

Value based on # fibers / area; not weight

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Second Layer: Open Cell Foam

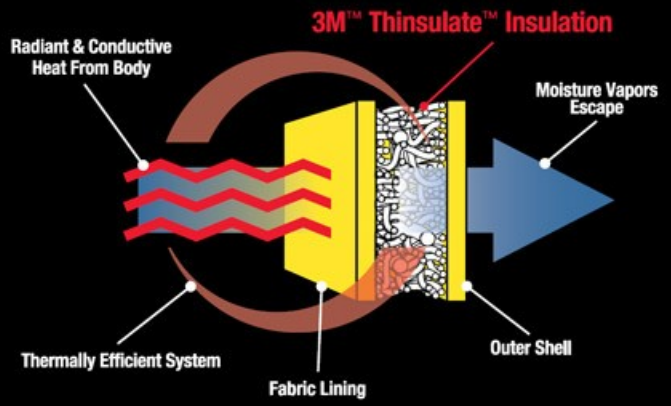
Synthetic foam open cell structure
First compression resistant underwear
Warm when dry
Holds insulation at depth
Rapidly loses insulation when wet

Foam structure a bit non-flexible

Second Layer: Type b Marine Thinsulate

Synthetic microfilament polypropylene
Compression resistant
Warm when dry
Holds insulation at depth
Holds insulation (~85 %) when wet

Expensive
Best insulation for wet environments



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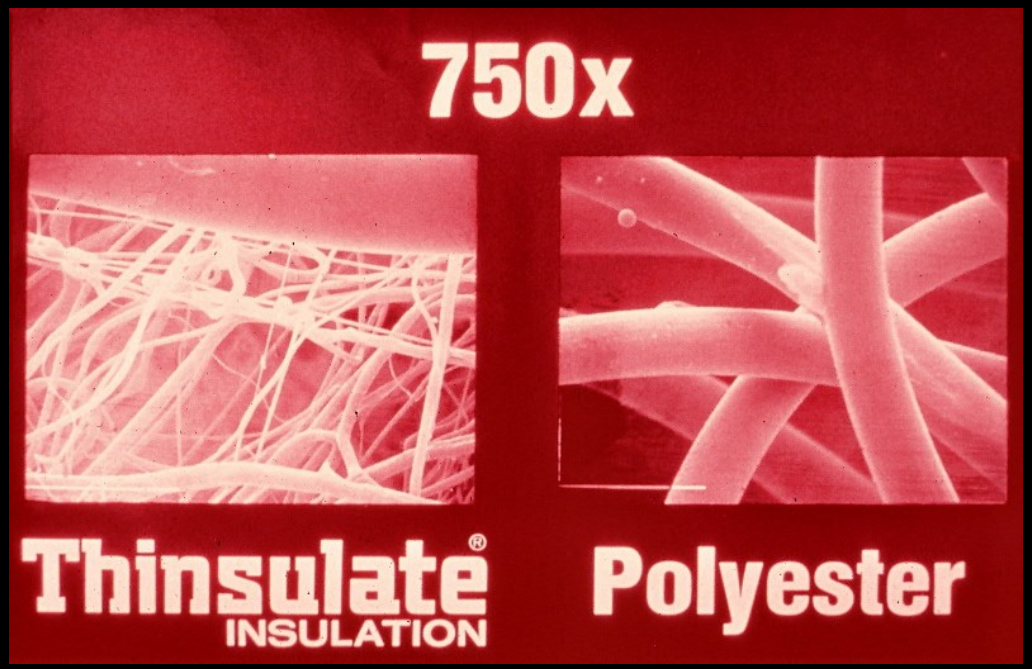
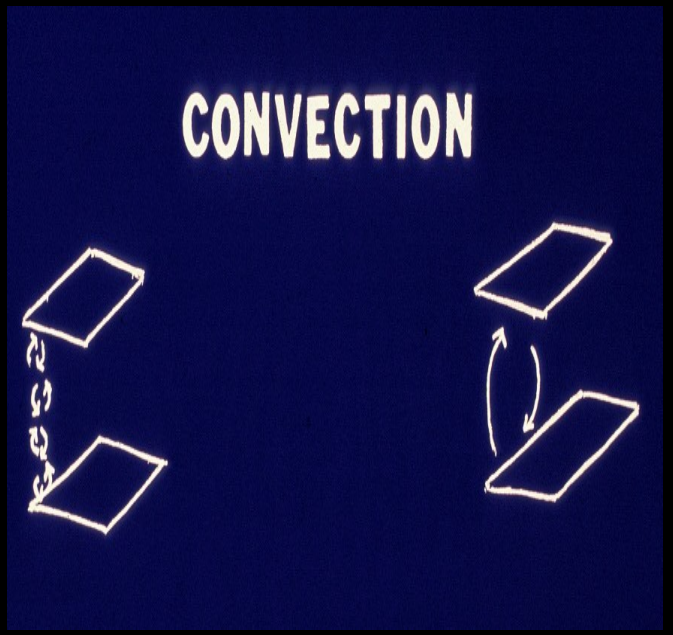
Second Layer: Type b Marine Thinsulate



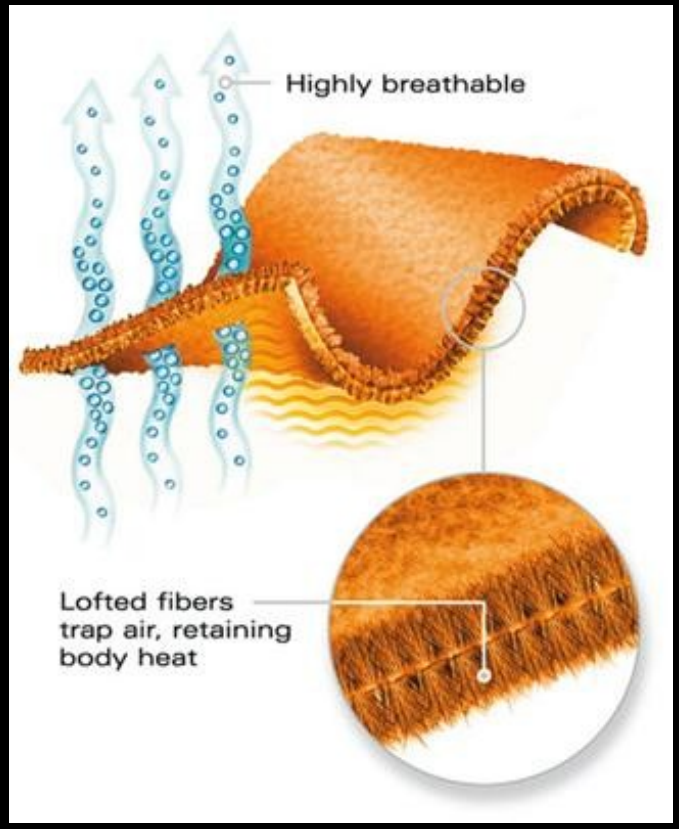


Smaller cell size traps more air (insulator)

Requires more convective / conduction steps to transverse garment

Second Layer: Polartec

Polatec: series of > 300 synthetic hydrophobic fabrics
Polyester: polyethylene terephthalate (PET)
Napped (fuzzy) insulator
Can serve as
Layer 1
Layer 1 & 2 combined
Layer 1, 2 , & 3 (with waterproof shell)
Depends on weight and design of fabric



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Second Layer: Radiant Barrier

Metallic heat reflective coat underneath cloth layer

Radiant barriers work extremely well in a vacuum
Reasonable in sealed, dry, surface garments
Not effective underwater

Experimental in the 1980's
Sold under brand name Underwave
Did not stay long on the market
Occasionally surfaces on e-bay

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Second Layer: Blue Heat

Active electrical heating system
Boots, gloves, and full torso sold separately

Lasts about 2 hours on 100% power
Designed to supplement, not replace, thermal undergarments
Very expensive

Concern that heating may increase DCI risk
- Use on lowest power
- Best used on final ascent

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Second Layer: Insulating Gas

Primary insulation:
Thermal resistance of gas in the suit

Thermal conductivity: ***the quantity of heat transmitted through a unit thickness of a material - in a direction normal to a surface of unit area - due to a unit temperature gradient under steady state conditions*** **(measured in watts per meter Kelvin, W/(m · K).**
Examples:

Air, atmosphere	**(gas)**	**0.024**
Argon	**(gas)**	**0.016**
Carbon dioxide	**(gas)**	**0.0146**
Helium	**(gas)**	**0.142**
Nitrogen	**(gas)**	**0.024**
Water	**(liquid)**	**0.58**

The lower the value,
The better the insulation

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Second Layer: Insulating Gas

Carbon Dioxide (CO_2)

Tried because of thermal conductivity

Readily available and inexpensive

$CO_2 + H_2O \rightarrow H_2CO_3$ (carbonic acid)

Carbonic acid creates itching and rashes

Argon (Ar)

Studies show little value (as practiced) when used with air diving

(Effective with 6 fill/empty cycles to provide all Argon insulation)

Valuable when diving tri-mix (N_2, He, O_2; heli-air) or heliox

(Can't use breathing gas 'cause of heat loss with helium)

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Second Layer: Argon Inflation System

Valve on Bottom
Easier to control

Connects to Suit Inflator

May need 2 cylinders:
One to fill/flush 6 times
One for dive

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Second Layer: Aerogel ?

Low density, open-cell nanopore structure
~ 20 nm cells approximate air molecule movement in vacuum
Structure is ~ 95% air

Extremely low thermal conductivity

Expensive: US Navy experimental dive suit: $ 5,200,000
Underwear: $ 1,200,000

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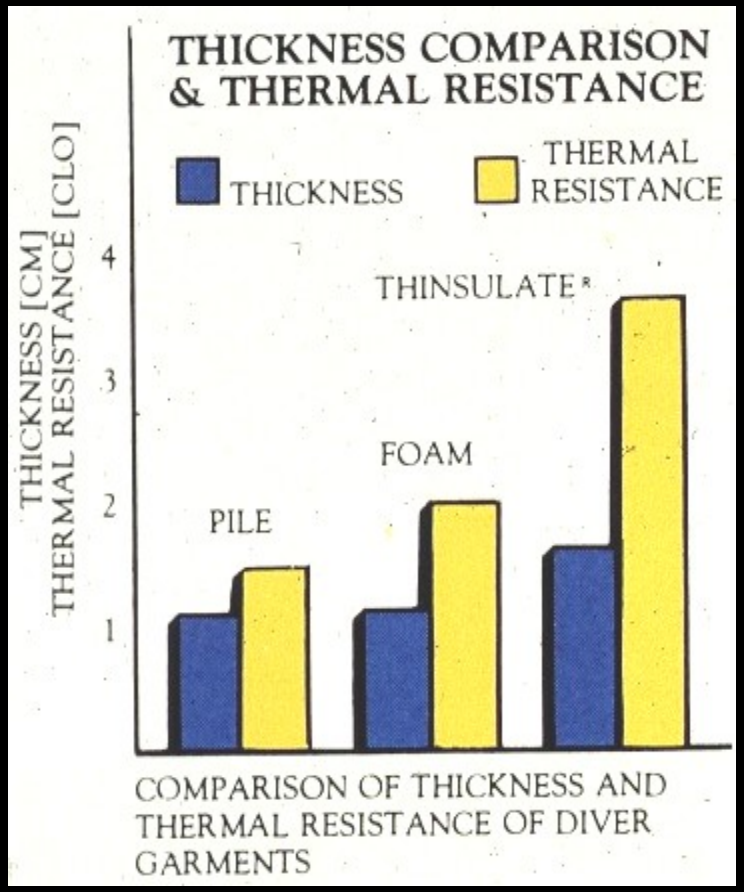
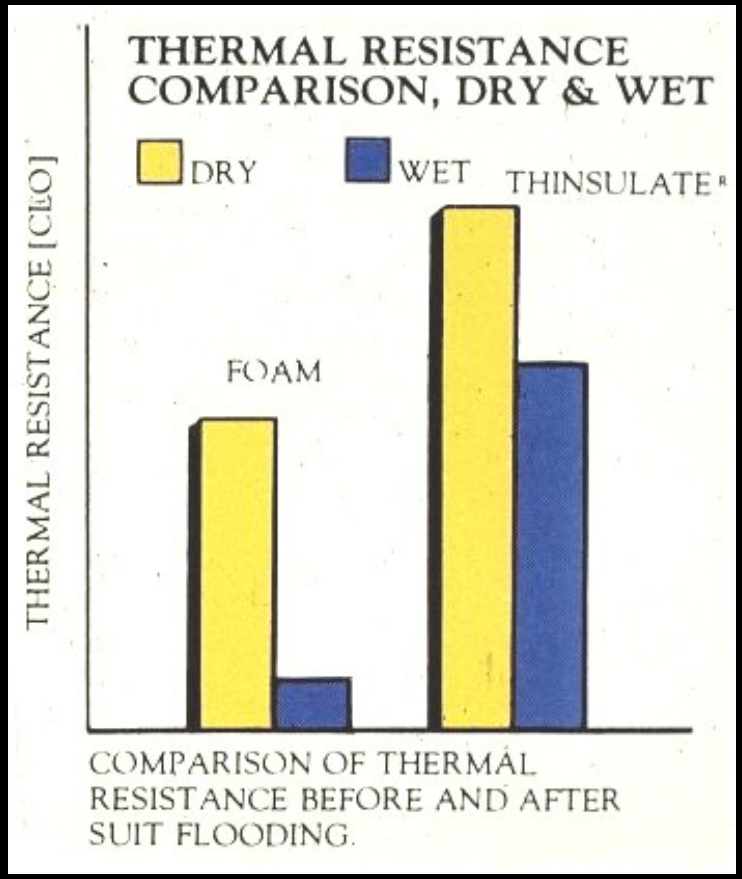
Insulation Value Comparisons





Thinsulate holds thermal protection even when submerged

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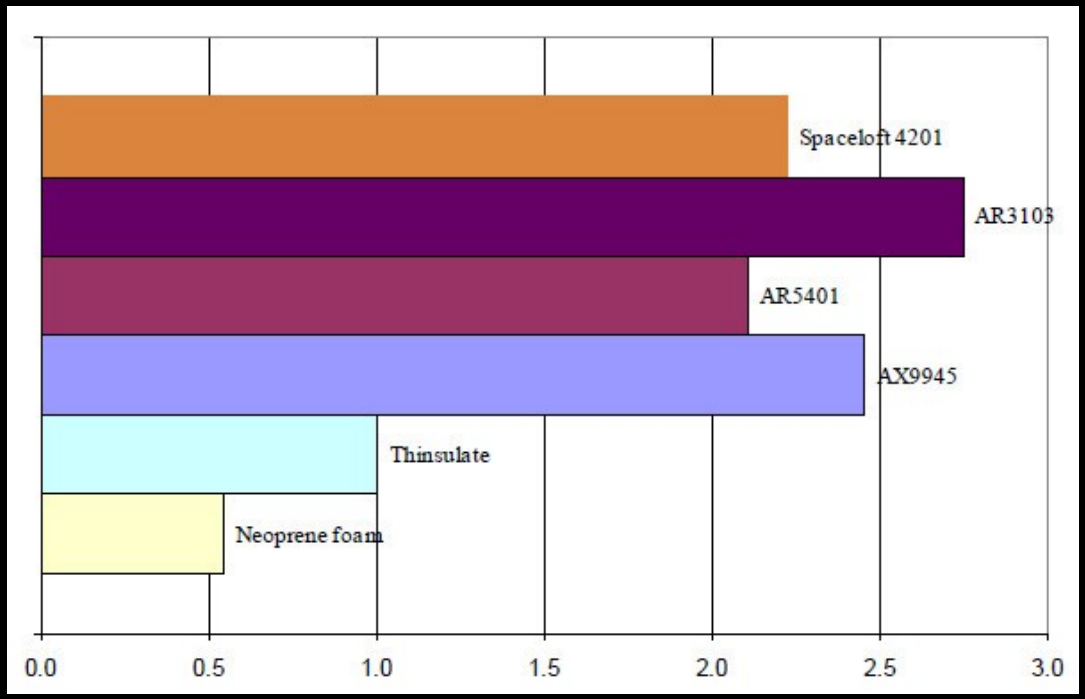
Insulation Dry Value Comparisons



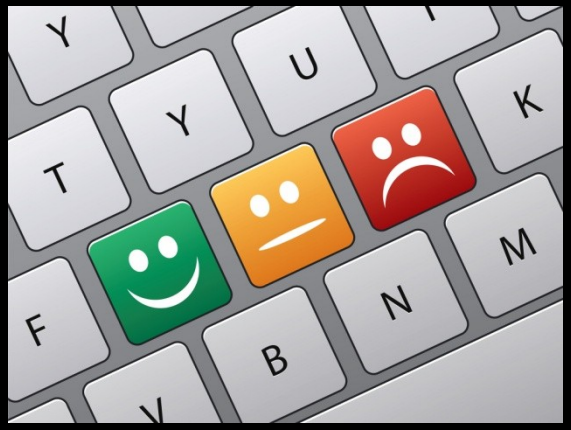
Top four are aerogels

LPT

Diver Ratings Of Underwear

Insulation Value	Comfort	Insulation When Wet
Thinsulate	Pile	Thinsulate
Foam	Thinsulate	Pile
Pile	Foam	Foam

Overall: Thinsulate Preferred



LPT

From 1982: Personal Test of Diving Underwear

THERMAL EVALUATIONS: TESTS

3/16" DUI "CAT" SUIT
1/4" COLD WATER HOOD
3-FINGERED MITTENS

FIRST LAYER: POLYPROPYLENE

50 F FRESH WATER
LITTLE MOVEMENT

UNDERWEAR	TIME TO FIRST SHIVER
BUNTING/ RADIANT BARRIER	28 MINUTES
ACRYLIC PILE	68 MINUTES
OPEN-CELLED FOAM	88 MINUTES
THINSULATE (C2)	128 MINUTES

LPT

From 1982: Personal Test of Diving Underwear

THERMAL EVALUATIONS : CONTROL

1/8" HOODED "CHICKEN VEST"
1/4" FARMER JOHN WET SUIT
1/4" COLD WATER HOOD
1/4" 3-FINGERED MITTENS

50 F FRESH WATER
LITTLE MOVEMENT

TIME TO FIRST SHIVER = 55 MINUTES

LPT

Underwear Selection Bottom Line:

No single underwear package will
Work in all combinations of water temperature and workload

Divers need multiple packages
Experience needed to match package with diving conditions

Multiple divers on the same site may have different packages
But, each will have individually correct system for their needs

LPT

DUI'S

Thermal Guidelines

THERMAL STRESS IS

The Greatest Limiting Factor
In Diving Today

THERMAL STRESS IS

Tolerated In Most Diving Operations
Which Is A Mistake

THERMAL STRESS IS

A Factor In Most Diving Accidents

LPT

THERMAL STRESS IS

Predictable And Preventable

People Produce **HEAT** At Different Rates

People Lose **BODY TEMPERATURE** At Different Rates

OUR GOAL:

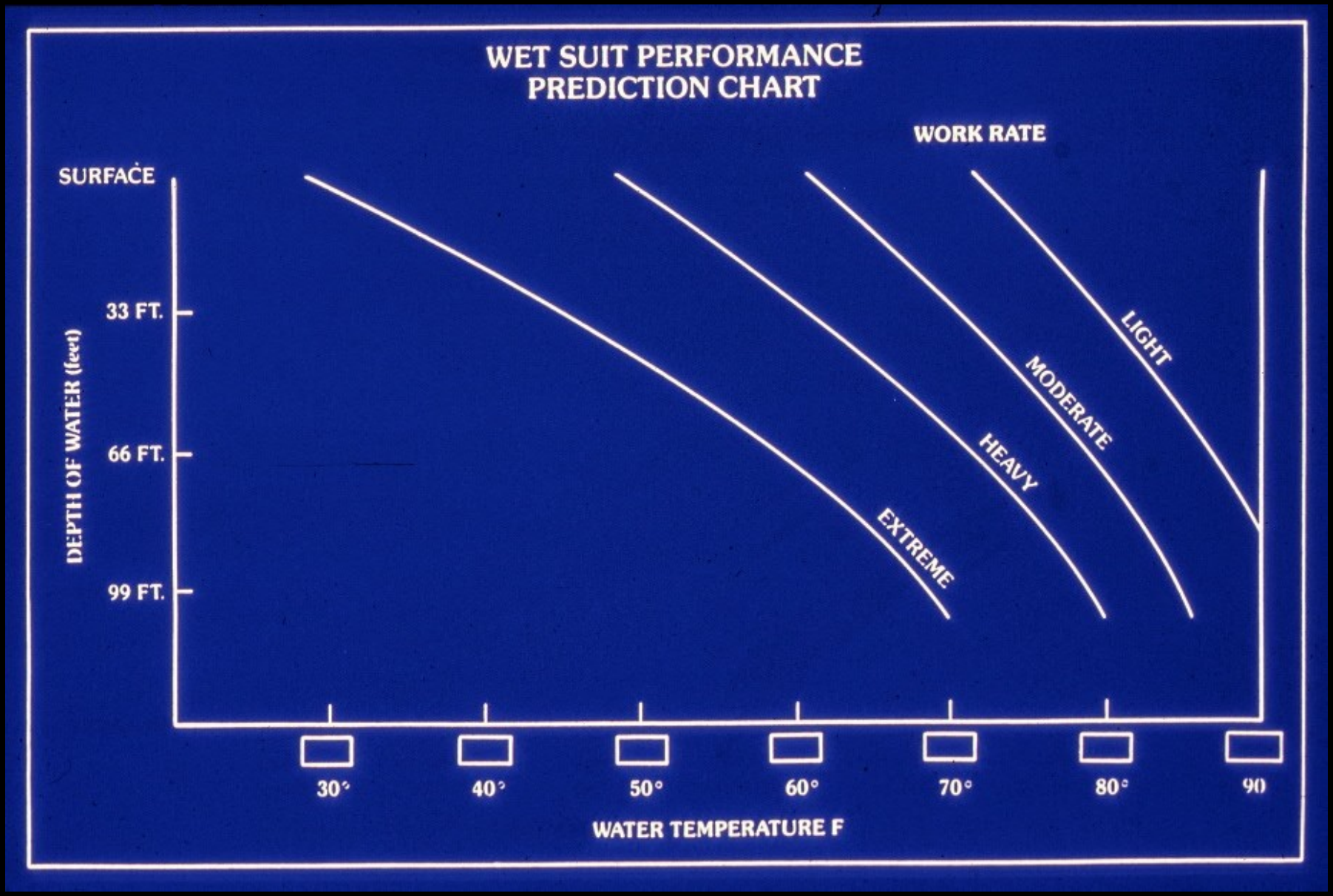
Each Diver Performing At 100% Efficiency And Reliability

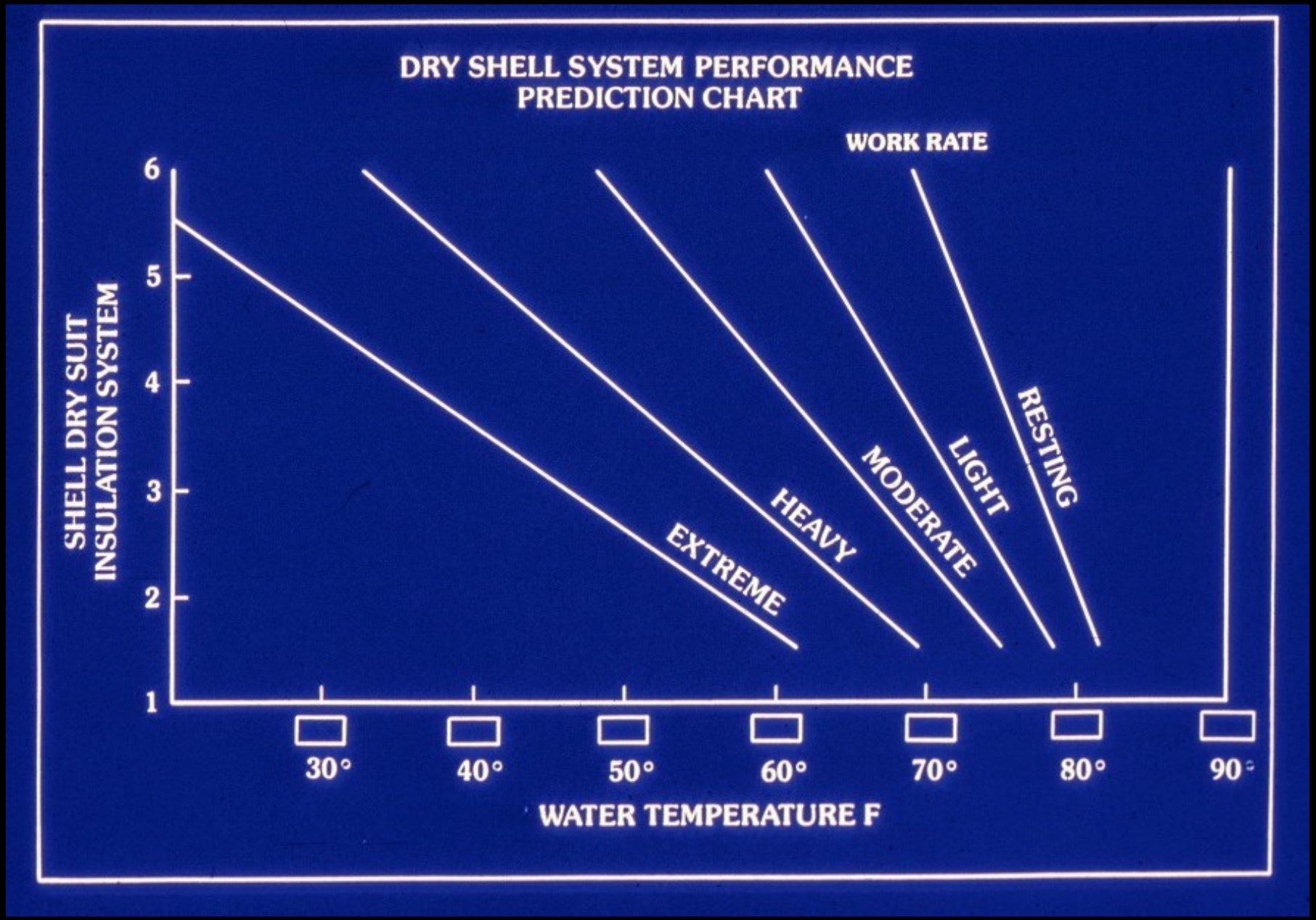
EXERCISE RATE

Light - Taking Photographs Or Observing

Moderate - Normal Swimming

Heavy - Strong Swimming Or Dragging An Object Across The Bottom


WET SUIT PERFORMANCE
PREDICTION CHART
WORK RATE
SURFACE
33 FT.
66 FT.
99 FT.
DEPTH OF WATER (feet)
LIGHT
MODERATE
HEAVY
EXTREME
30°
40°
50°
60°
70°
80°
90
WATER TEMPERATURE F


DRY SHELL SYSTEM PERFORMANCE
PREDICTION CHART
WORK RATE
SHELL DRY SUIT
INSULATION SYSTEM
6
5
4
3
2
1
EXTREME
HEAVY
MODERATE
LIGHT
RESTING
30°
40°
50°
60°
70°
80°
90°
WATER TEMPERATURE F

PLUS RATING TABLE

Your Body Weight

		90	105	120	135	150	165	180	195	210	225	245
-4	-2	0	+2	+4	+6	+8	+10	+12	+14	+16	+18	+20

Degrees

Find Your Plus Rating As Listed Below Your Body Weight

IF COMFORTABLE

- No Modifications

Example: 165 Lb. Person Is a +10

IF TOO WARM

- Open Collar Shirt
- Loose Clothing
- Move Up 2°

Example: +10° To +12°

IF YOU PERSPIRE

- Move Up 4°

Example: +10° To 14°

IF TOO COLD

- Button Up
- Wear Long Sleeves
- Move Down 2°

Example: +10° To +8°

NEED A SWEATER

- Move Down 4°

Example: +10° To +6°

IF YOU USE

A DUI CF 200 Dry Suit

- Move Up 4°

Example: +10° To +14°

DIVER _____

DRY SUIT + 10 DIVER

ACTIVITY Heavy	Moderate	Light		Insulation Level	Weight Added Salt	Fresh
Water Temp °F						
74	78	82	A	Expeditionary weight polypropylene underwear		____
64	72	76	B	Single layer bunting or lightweight pile*		
54	63	70	C	50°-65° DUI Thinsulate divewear*		
47	58	66	D	Double weight bunting* DUI pile plush, heavy-weight high quality pile* or V. foam	____	____
34	48	60	E	35°-50° DUI Thinsulate divewear*	____	____

Note: Includes appropriately matched boots and gloves.
*Also includes medium weight polypropylene underwear.

WET SUIT + 10 DIVER

WATER Depth Feet	ACTIVITY Heavy	Moderate	Light
	Water Temp °F		
0'	48	62	72
33'	60	70	80
66'	72	78	88
99'	78	84	

Temperature in order to be at thermal equilibrium

AUXILIARY INSULATION

Degrees F	Insulation	Weight Added Salt	Fresh
+5° to +10°	Back-packing bunting or pile suit top and bottom	_____	_____
+10°	Heavy polyester or poly nylon sweat pants and shirt	_____	_____
+5° to +7°	Heavy jogging suit	_____	_____
+5°	Mountaineering expedition weight or wool polypropylene top and bottom	_____	_____
+5° to +7°	Heavy wool/acrylic sweater	_____	_____
+5°	DUI plus 5 vest	_____	_____

EFFICIENCY AND RELIABILITY

TEMP	WET SUIT DIVE NUMBER 1st	2nd	3rd	DRY SUIT DIVE NUMBER 1st	2nd	3rd
70°F	100%	100%	100%	100%	100%	100%
60°F	100%	90%	80%	100%	100%	100%
50°F	80%	70%	50%	100%	100%	100%
40°F	50%	25%	*	100%	85%	75%
32°F	*	*		100%	75%	55%

*Not recommended unless involved in a life saving rescue.

Table based on 30 minute dives at depth of 50 feet.

MISERY INDEX

TEMPERATURE DIFFERENCE FROM THERMAL COMFORT °F	FOR DIVES LONGER THAN 20 MINUTES BUT LESS THAN 60 MINUTES RESULT
-5°	Diver will rewarm between dives.
-10°	Outer body shell will accumulate thermal debt, but can be tolerated.
15°	Degrade diver in water performance and accumulate body shell thermal debt.
20°	Significant performance degradation, poor efficiency.
-25°	Reduce diver to shivering and misery.
-30°	Should not be attempted.
+5°	Can be tolerated, take off glove or ventilate water through hood.
+10°	Must be careful, watch for signs of heat prostration. If occurring, terminate dive.
+15°	Substantial heat build-up, can lead to disastrous results.

DUI INC.

Diving Unlimited International • 1-800 327-8439
1148 Delvan Drive, San Diego, CA 92102-2499

A DUI dry suit is thermal insurance where the dividend is always more than the premium.

WET SUIT + 10 DIVER

WATER Depth Feet	ACTIVITY Heavy	Moderate	Light
	Water Temp °F		
0	48	62	72
33	60	70	80
66	72	78	88
99	78	84	

Temperature In Order To Be At Thermal Equilibrium

MISERY INDEX

Dives Longer Than 20 Mins. But Less Than 60 Mins.

TEMPERATURE DIFFERENCE

-5° Diver Will Rewarm Between Dives

-10° Outer Body Shell Will Accumulate Thermal Debt, But Can Be Tolerated

-15° Degrade Diver In Water Performance And Accumulate Body Shell Thermal Debt

TEMPERATURE DIFFERENCE

-20° Significant Performance Degradation, Poor Efficiency

-25° Reduce Diver To Shivering And Misery

-30° Should Not Be Attempted

TEMPERATURE DIFFERENCE

+5° Can Be Tolerated, Take Off Glove Or Ventilate Water Through Hood

+10° Must Be Careful, Watch For Signs Of Heat Prostration. If Occurring, Terminate Dive

+15° Substantial Heat Build-Up, Can Lead To Disastrous Results

COLD HURTS
HEAT KILLS

DRY SUIT + 10 DIVER

Activity: Heavy	Activity: Moderate	Activity: Light	Insulation Level	Weight Added: Salt	Weight Added: Fresh
	Water Temp °F				
34	48	60	E 35°-50° DUI Thinsulate Divewear*	—	—

Note: Includes Appropriately Matched Boots And Gloves. *Also Includes Medium Weight Polypropylene Underwear

DIVER _____

DRY SUIT + 10 DIVER

Activity: Heavy	Activity: Moderate	Activity: Light		Insulation Level	Weight Added: Salt	Weight Added: Fresh
	Water Temp °F					
74	78	82	A	Expeditionary weight polypropylene underwear	____	____
64	72	76	B	Single layer bunting or lightweight pile*	____	____
54	63	70	C	50°-65° DUI Thinsulate divewear*	____	____
47	58	66	D	Double weight bunting* DUI pile plush, heavy-weight high quality pile* or V. foam	____	____
34	48	60	E	35°-50° DUI Thinsulate divewear*	____	____

Note: Includes appropriately matched boots and gloves.
*Also includes medium weight polypropylene underwear.

DIVER _____

DRY SUIT + 10 DIVER

Activity: Heavy	Activity: Moderate	Activity: Light		Insulation Level	Weight Added: Salt	Weight Added: Fresh
	Water Temp °F					
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34	48	60	E	35°-50° DUI Thinsulate divewear*	____	____

Note: Includes appropriately matched boots and gloves.
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DRY SUIT + 10 DIVER

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	Water Temp °F				
34	48	60	E 35°-50° DUI Thinsulate Divewear*	—	—

Note: Includes Appropriately Matched Boots And Gloves. *Also Includes Medium Weight Polypropylene Underwear

AUXILIARY INSULATION

Degrees F	Insulation	Weight Added Salt	Weight Added Fresh
+5° To +10°	Back-Packing Bunting Or Pile Suit Top And Bottom	—	—
+10°	Heavy Polyester Or Poly Nylon Sweat Pants And Shirt	—	—
+5° To +7°	Heavy Jogging Suit	—	—
+5°	Mountaineering Expedition Weight Or Wool Polypropylene Top And Bottom	—	—
+5° To +7°	Heavy Wool/Acrylic Sweater	—	—
+5°	DUI Plus 5 Vest	—	—

EFFICIENCY AND RELIABILITY

Temp	Wet Suit Dive Number			Dry Suit Dive Number		
	1st	2nd	3rd	1st	2nd	3rd
70°F	100%	100%	100%	100%	100%	100%
60°F	100%	90%	80%	100%	100%	100%
50°F	80%	70%	50%	100%	100%	100%
40°F	50%	25%	*	100%	85%	75%
32°F	*	*	*	100%	75%	55%

*Not Recommended
Table Based On 30 Minute Dives At Depth Of 50 Feet

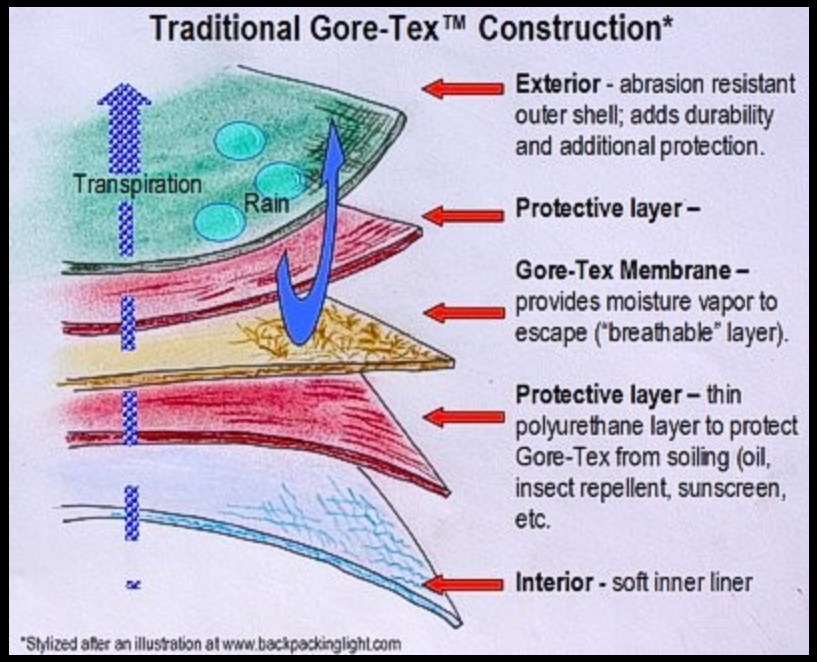
TOTAL COMFORT

LPT

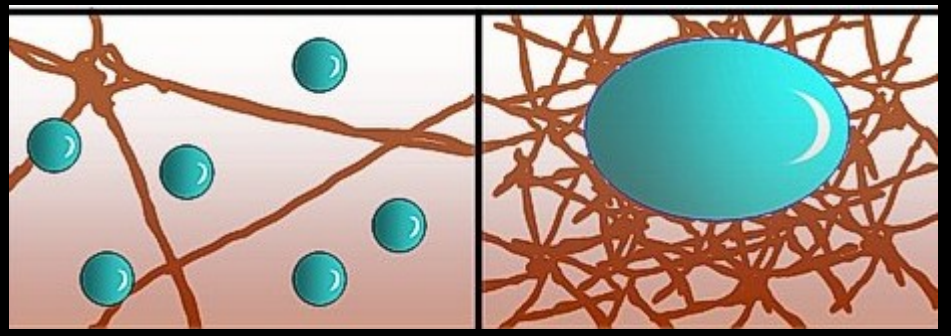
Third Layer: Gore Tex

Short for Gore's textile fabric

Used for outdoor wear; not intended for in-water use



Gore Tex membrane:
Excludes water droplets
Passes water vapor



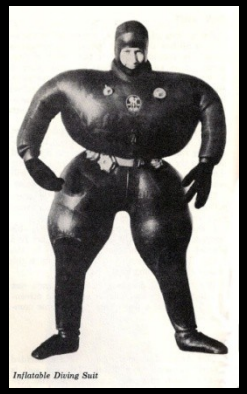
9 billion pores per square inch
Each pore 20,000 x smaller than water droplet

Wash with warm water & breathable fabric detergent; no fabric softener or bleach

LPT

Third Layer: Dry Suit

Keeps the insulation dry
Protects insulation from abrasion
Allows efficient, reliable cold water diving



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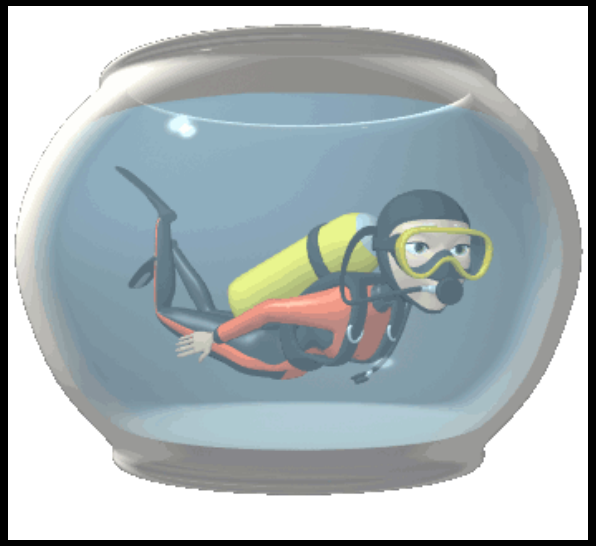
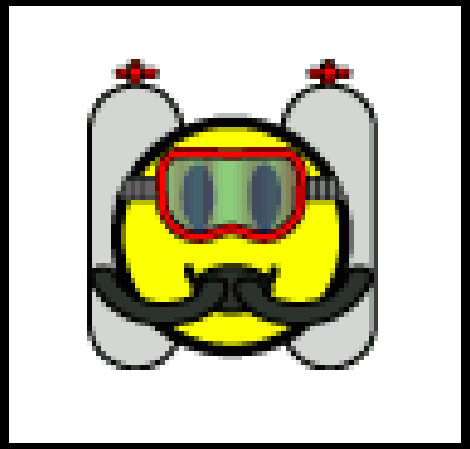


Wet vs. Dry Suits



LPT

Summary of Wet Suit Properties

Insulation: gas trapped in neoprene material
tight fit restricts water flow (conductive / convective heat loss)

Advantages: inexpensive
reasonable protection in temperate water environments
rapid deployment

Disadvantages: insulation (gas bubbles) decreases with depth
insulation decreases with age (gas bubble cells rupture)
buoyancy decreases with depth
ineffective in water below 60 ^{o}F
wind-chill on the surface
needs close fit
rush of cold water on entry
repair only when dry
chill increases air consumption

LPT

Summary of Dry Suit Properties

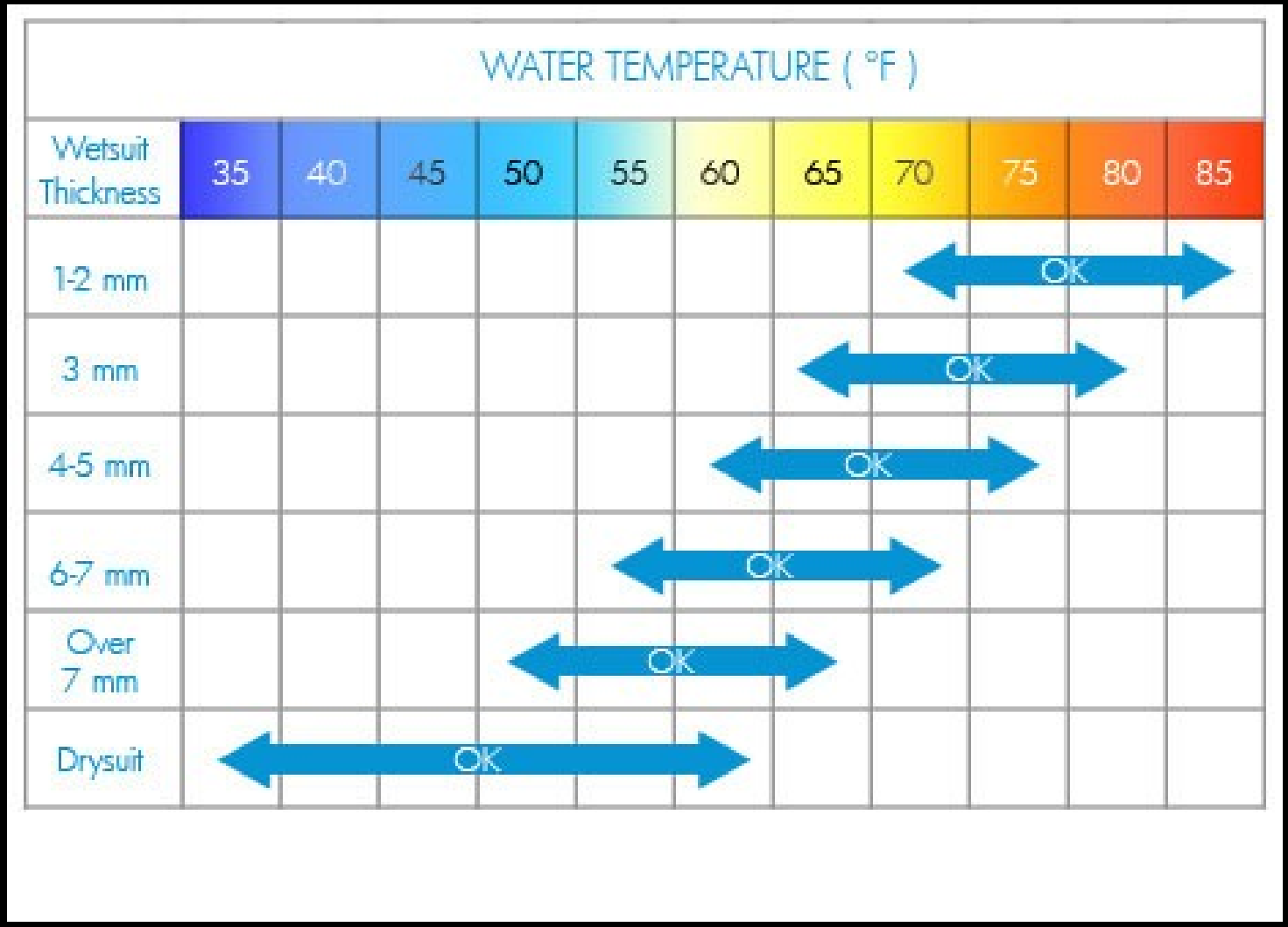
Insulation: separate from outer shell
variable to match diver to water temp, work load and comfort

Advantages: constant insulation thermal protection
constant insulation buoyancy
don't need perfect fit
easy field repairs
no cold water rush on entry
consistent air consumption
longer "dive season"
Reasonable post-dive thermal protection

Disadvantages: expensive
requires multiple undergarment packages
specialized training to use efficiently
longer deployment time
can overheat on surface
require more weight than wet suit

LPT

General Guidelines for Personal Thermal Protection



Cold Water is defined as < 70 º F

LPT

Suit Thickness

mm	inches
2	0.089
3	0.118
4	0.157
5	0.197
6	0.236
7	0.276
8	0.315
10	0.394
12	0.472
14	0.551

Can be listed in either Metric or English Units

Fraction	Decimal
1/8	0.125
1/4	0.250
1/2	0.500

LPT

Wet vs Dry Suits

WETSUITS

-Warmth from water trapped close to skin

-Wet = Warm

-Neoprene insulation

-Inexpensive option

-Multiple styles

-Multiple thicknesses

DRYSUITS

-Warmth from full body protection

-Wrist and neck seals

-Integrated booties

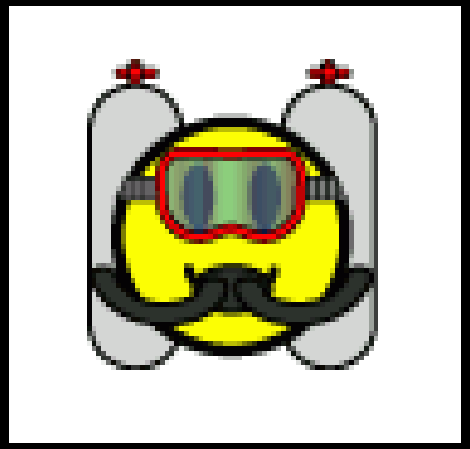
-Fully waterproof

-Loose fitting

-Expensive

LPT

Dry Suits: Styles



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Style: Canvas and Latex

- Historically, first in common use
- Mainstay of commercial & military salvage
- Used with “hard hat”
- Required heavy weights to offset buoyancy
- Required surface support crew
- Out-dated (except for Hollywood)

LPT

Style: Uni-Suit

Thick (6.5 mm) foam neoprene
(wet suit with wrist & neck seals)
Extremely buoyant
Required ~40 pounds weight
Valve placement awkward to vent
Designed to use without BCD
Very rugged
Not designed for swimming;
For commercial / military salvage divers

Out dated technology

LPT

Style: Vinyl

- Inexpensive
- Non-breathable
- Stiff
- Not very rugged
- Very little use in diving
- Commonly used in rain and sauna suits
- Outdated dry suit technology

Style: “Pack Cloth”

- Polyurethane laminate: urethane coating on nylon
  - Nylon weight/thickness described as denier
  - Higher the denier value, the thicker the fabric
- Inexpensive, introduced dry diving to many
- Not compression at depth
- More reliable than foam
- No inherent thermal protection
- Easily repaired
- Not too flexible; like “diving in a garbage bag”
- Some movement of air with position change
- 1980’s technology

Style: Tri-laminate (TLM)

Three layers: polyester, butyl rubber, and polyester
  Butyl rubber layer increases flexibility
Material originally developed for NATO chemical warfare
Combines light weight with excellent abrasion resistance
Resistant to chemicals, ozone , and smog
Quick and easy to repair
With telescoping zipper, can obtain a more snug fit
Responsible for increased popularity of dry suit diving

May de-laminate with time
Thinner (not as much thermal insulation as neoprene)
Also called a membrane suit

LPT

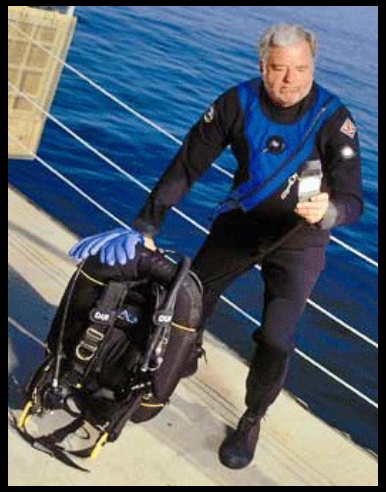
Style: Vulcanized Rubber

Commercial, military, high end recreational
No seams … suit is vulcanized to single unit
Waterproofing on outside
Generally loose fit
Durable
Easily repaired
Usually zipper across the back
Expensive (but, cost effective for avid diver)

Used in Hazmat diving
rubberized exterior easily decontaminated

LPT

Style: Crushed Neoprene



Crushed neoprene (DUI's CLS 200)
CF 200 between layers of nylon
True 4-way stretch
Extremely rugged (most durable suit made)
Can be tailored (many options) to individual needs
Some inherent thermal protection
Telescoping torso
Self-don zipper
Must be dry to repair
Very little internal volume (less air movement)
Expensive (but , cost effective for avid diver)

My CF 200x suit (purchased 1984) still viable.

LPT

Style: Mixed CF 200 & TLM

Crushed neoprene bottom for strength and durability
Top portion TLM for lightness and comfort
Less expensive than full CF 200 suit

LPT

Haz-Mat Suits

Totally Encapsulated
Dual Seal Valves
Extremely Rugged
Require mated helmet

DUI CXO

AquaLung HazMat

Viking HD

LPT

Hard Shells

1 Atmosphere Systems

Very expensive

Require Surface Support

Newt

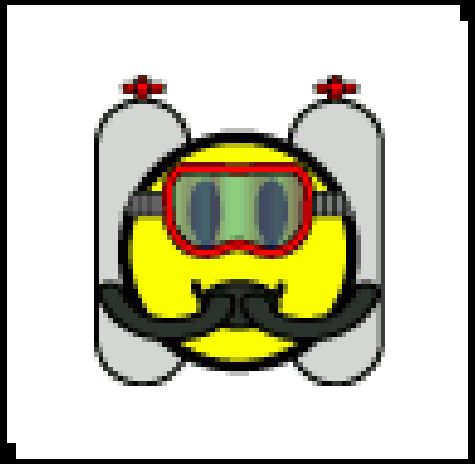
Exo

Jim

Sea Wasp

LPT

Seam Construction



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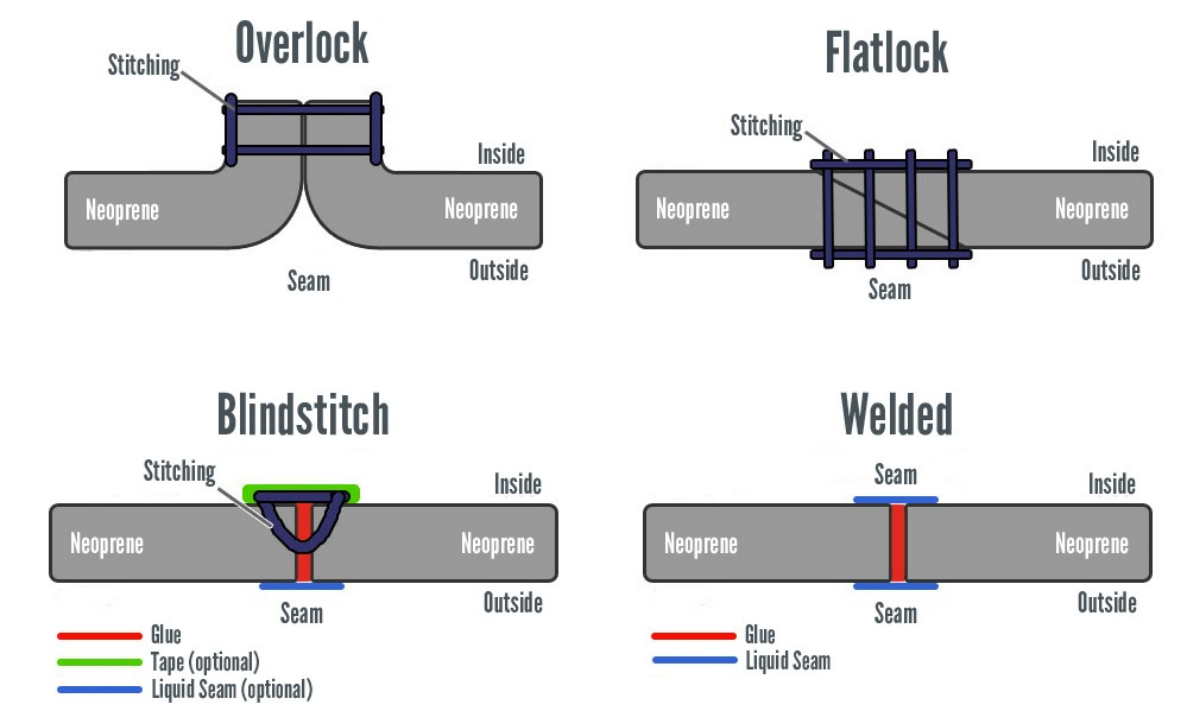
Seam Construction: Foam Neoprene

Like a wet suit: Glued and Sewn



The more steps, the better the seal, the greater the cost

LPT

Seam Construction: Vulcanized Rubber

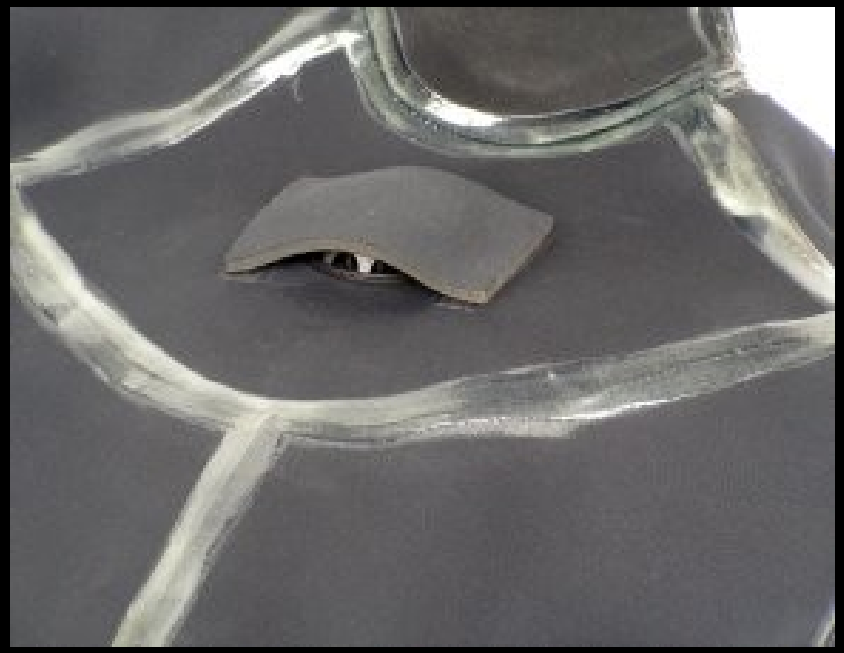
- No seams
- Suit assembled with uncured rubber
- Entire outer shell vulcanized
  - Provides single continuous coating
  - Difficult to alter
  - Difficult to tailor to individuals

LPT

Seam Construction: TLM & CF 200

Material sewn (typically 7 threads) , then glued
Nylon inner coating removed at seam
Elastomer coating applied
Seams taped

Very durable
Commercial grade suits:
Heavier seal (worth the price)



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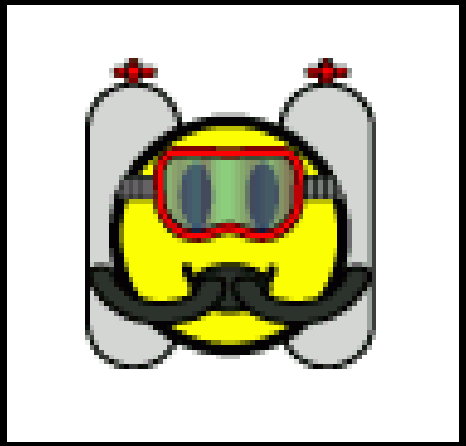
Neck Seals



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Neck Seals: Neoprene

1/8” neoprene “fold-under”
Strong
Little stretch
Some thermal protection
Most popular neck seal
Longer life than latex

After dive: dry, rub with unscented talc

Measure and trim carefully … too tight can restrict breathing

LPT

Neck Seals: Latex

Thin latex cone

Comfortable

Somewhat fragile

Enormous stretch

No thermal protection

Must trim latex cone to neck size

After dive: dry, rub with unscented talc

Measure and trim carefully … too tight can restrict breathing

LPT

Neck Seals: “Bellows-Style” Latex

Thin latex cone with bellows
Comfortable
Somewhat fragile
Enormous stretch
No thermal protection
Must trim latex cone to neck size
Designed for very large or very small necks

After dive: dry, rub with unscented talc

LPT

Neck Seals: Latex (Viking)

A more robust “bellows” seal

LPT

Neck Seals: SI Tech Quick Neck

SI-Tech Latex Quick Neck
Glue ring to neck area of suit
Use tool to attach latex neck seal

LPT

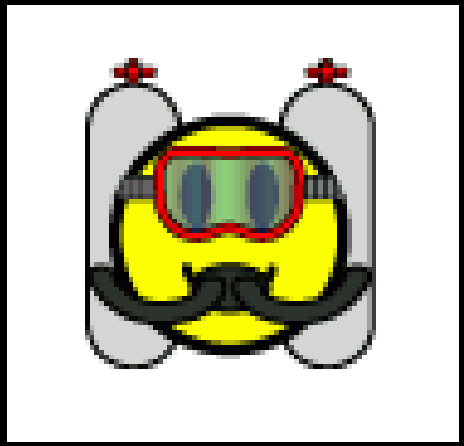
Neck Seals: ZIP (DUI)

Latex or Silicone
Allows rapid replacement
Groove on neck seal fits into slot on suit

Neck Seals: Apollo Bio-Seal

Cosmo gel (1500 % stretch)
Adds additional sealing surface
Extremely rugged

Wrist Seals



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Wrist Seals Neoprene

Neoprene core

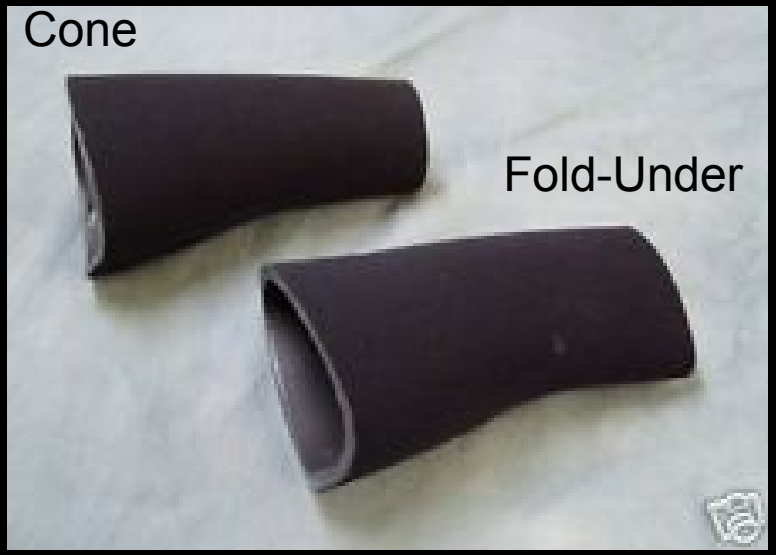
Two types: cone (most common) & fold under (warmest)

Lycra (for strength) outer covering

Only expands 106 % (slows entry and exit)

Warmer than latex

Problem: small leaks along “wrist channels” (from flexing)



Store in bag containing unscented talc

LPT

Wrist Seals Latex

Driest Seal
Latex expands 400% (easy entry and exit)
Expansion useful for a variety of glove systems
Short life-time (gets gummy with time)
Typically sold very long; need to trim to size
Two major styles: bottle or cone
Fit critical with bottle seal

Store in bag containing unscented talc

LPT

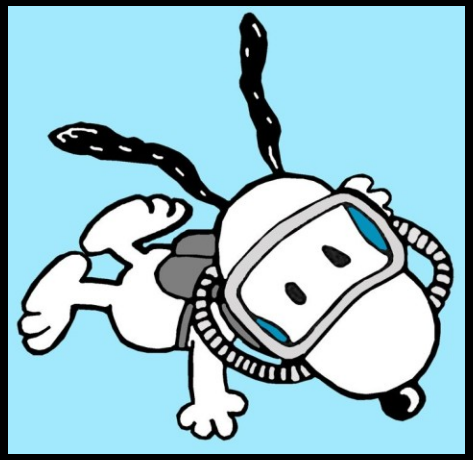
Wrist Seals ZIP (DUI)

Latex or silicone
Designed for easy replacement of old/broken seals
Suit has fitting on wrist
ZIP cone is inserted into wrist ridge and cut to size
Zip can be added (send dry suit to DUI) to any suit

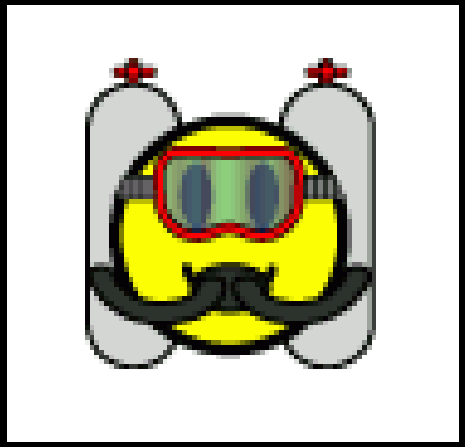
LPT

Wrist Seals: Apollo Bio-Seal

Cosmo gel (1500 % stretch)
Adds additional sealing surface
Extremely rugged



Valves



LPT

Valves: Inflation

Chest Mounted

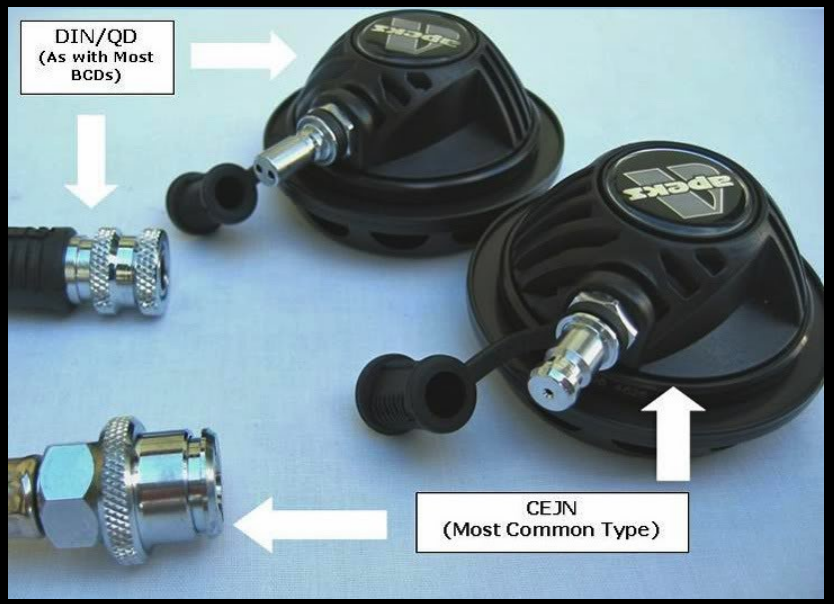
Press to inflate suit

Allows suit inflation to offset suit squeeze

Two connector styles:

DIN /QD (Like BCD fitting)) and CEJN (easier release)

Proper hose comes with the valve



LPT

Valves: Inflation

Desirable features:

- **Easy to operate with thick gloves/mittens**
- **Easy to connect / disconnect with gloves/mittens**
- **No sharp edges**
  - **Sharp edges on valves major source of dry suit punctures**
  - **Always store inflator valves with protective cap**
- **Self-don zippers: arrange hose parallel to zipper**

Cover Guard

// to zipper

LPT

Valves: Inflation

Can open valve to examine seals
Do not use silicone oil or grease on seals
Cement inflator assembly to suit with aquarium cement
Do not use aqua seal

LPT

Valves: Haz Mat Inflation

- Has more chemically resistant seals
- Two different seals
- On-Off switch at the inlet valve
- Easy to operate with thick gloves/mittens

LPT

Valves: Deflation (Exhaust)

Usually shoulder mounted

Sometimes on wrist or lower leg

Allows release of air on ascent

Two types:

Push to deflate

Push to deflate with auto-dump

Valves: Deflation (Exhaust)

Desirable features:

Easy to reach / operate with gloves /mittens

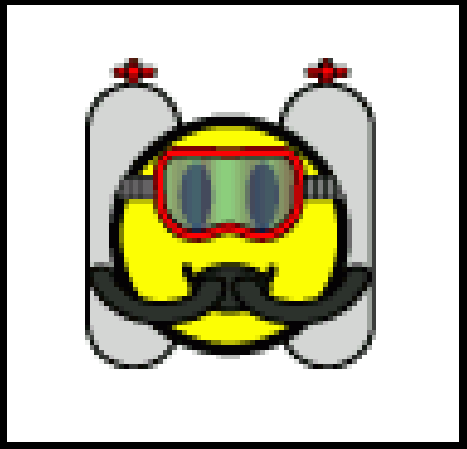
Auto-dump:

- **Can adjust release pressure**
- **Close on descent**
- **Open on ascent**
  - **Raise shoulder to level and valve auto-vents**

Set release pressure (1-10” water) by rotating ring
Requires experience to use effectively

LPT

Zippers



LPT

Zippers

Provides water proof seal of entry/exit point
Early seals same zipper as NASA space suits
Modern suits a bit cheaper
Two common placements: torso (self-don) & across shoulders

Zipper teeth hold rubber sealing surfaces together

LPT

Zippers: Between the Legs

Developed for Norwegian military
Crawl through seal to enter exit suit

Advantages:
Allows excretion without removing suit

Disadvantages:
Cumbersome entry
Requires assistance to open / close zipper
Requires careful aim

Zippers: Across the Back

Runs from one shoulder to the other across the back

Advantages:

Least expensive seal

Easy entry / exit

Disadvantages:

Tend to swim with bent arms

Extended crotch: extra air volume

Zipper vulnerable to back pack abrasion

Typically requires assistance to open / close zipper

LPT

Zippers: Torso or Self-Don

Runs diagonally across front
Extended (telescoping) torso
Enter suit, fold down torso

Advantages:

- Self-donning
- Snug fit with good flexibility
- Minimum extra air volume
- Can use as relief zipper
- Can use to ventilate between dives

Disadvantages:

- Expensive
- Possible wear on zipper

LPT

Zippers: Torso or Self-Don

Some suits include a cover to protect the self-don zipper

Zippers: Front

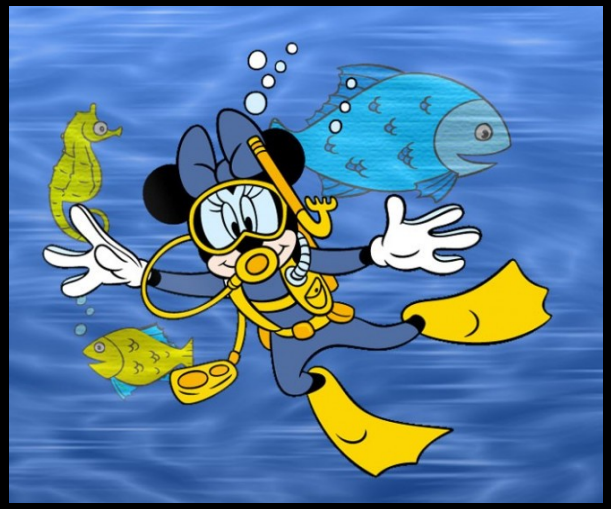
Zippers: Relief

More common on sailing & kayaking suits

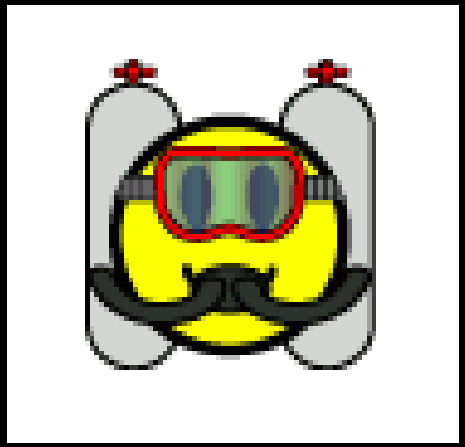
Offers another failure point

Redundant with self-don

LPT



Hoods



LPT

Hoods

Purpose: restrict heat loss from the head
This loss is not trivial

Need to protect head and neck

Hoods: Wet Suit

Commonly used

Must use hoods with little neck protection

Cold water designed to be under wet suit jacket

Not possible with dry suit neck seal

LPT

Hoods: Dry Suit

Thicker neck

Especially important for latex neck seals

DUI has insulated vented hood

Allows air bubbles to self-vent

LPT

“No-Nose” Hoods

Mask seals on outside
Slit for regulator

Unwise for full face masks

LPT

Hoods: Attached

Considered warmer

Viking has totally dry hood

Cumbersome to set up

Typically a commercial suit

Requires tender to assist

LPT

Hoods: Full Face Mask

Have soft rubber area for mask seal

Mask seals on outside of hood

Exo-26

Aga

Guardian

LPT

Surface Head Covering

Significant heat loss on surface :

- IR radiation from head
- Evaporative energy from hair and suit
- Wind chill

Best to keep head covered

LPT

Boots

Cheaper suits have socks: Require over-boot

Need room for insulation

Attached boots preferred

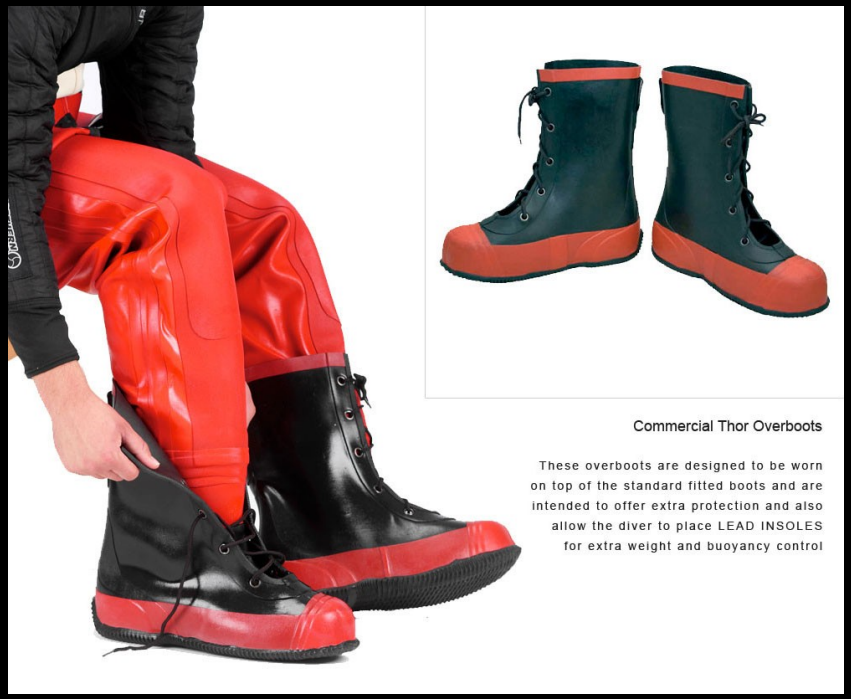
Can get variety of soles to suit diving sites

Over-Boots

For extreme needs of protection or traction

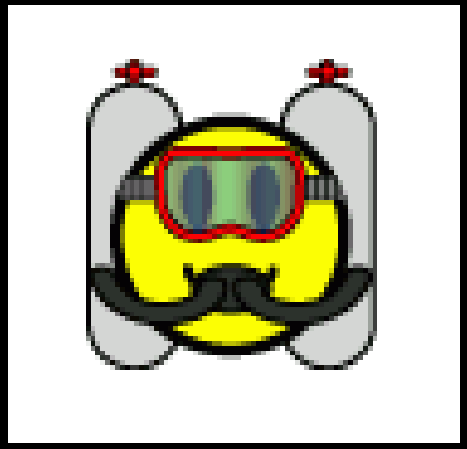
worn over attached boot

Worn over suits with socks



LPT

Gloves

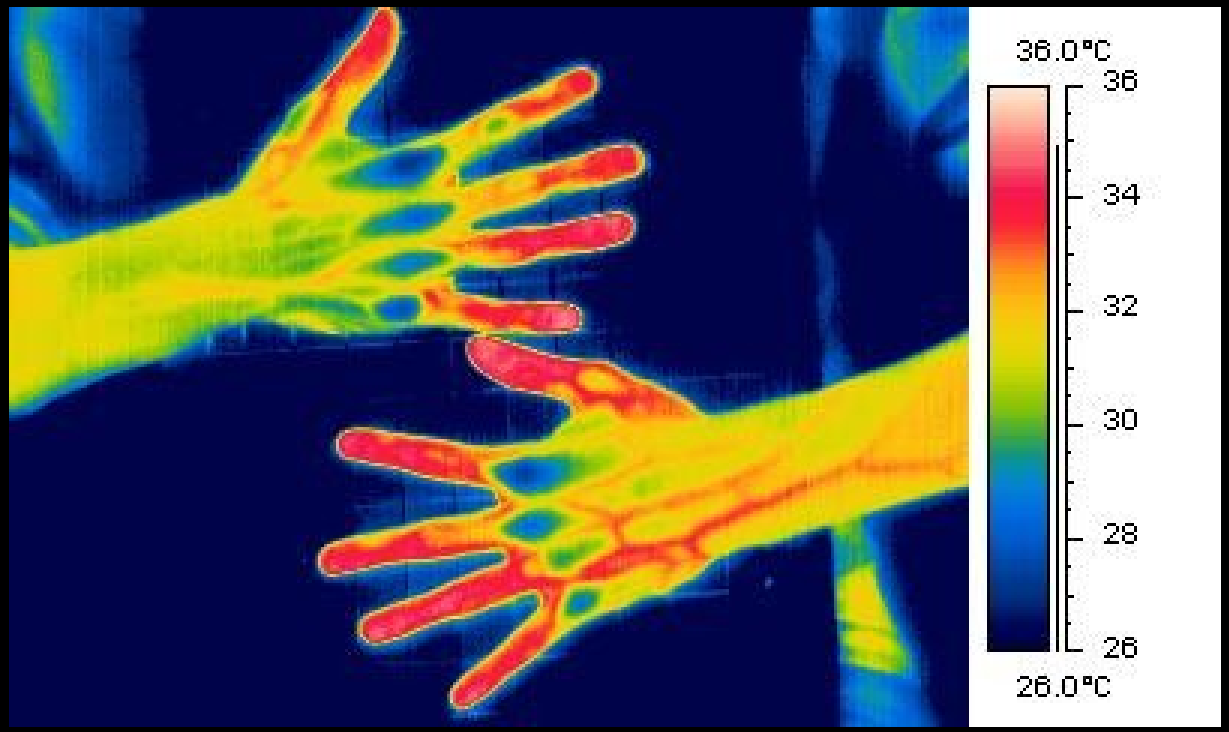


Gloves

No single glove or glove system perfect for all scenarios
Multiple diving profiles require different glove set up

Hands (especially fingers) easily chilled

Thermograph of hand area
Fingers → major source of heat loss



LPT

Gloves

5-finger wet suit gloves are inadequate
3-finger and mittens sometimes used
wet fingers rapidly lose heat

LPT

Gloves: Dry Gloves With Wrist Seal

Wrist seal on glove over lays wrist seal on suit

Putting on second glove cumbersome

LPT

Gloves: DUI Dry Gauntlet

Kevlar palm & fingers

Liner for warmth

Extra thickness on back of hand

Seals over wrist seal on suit

Putting on second glove cumbersome

LPT

Gloves: Rigid Wrist Rings

Rigid rings on glove and suit mate together

Keeps latex wrist seal intact

Room for multiple different thermal linings

Started “dry hands” technology

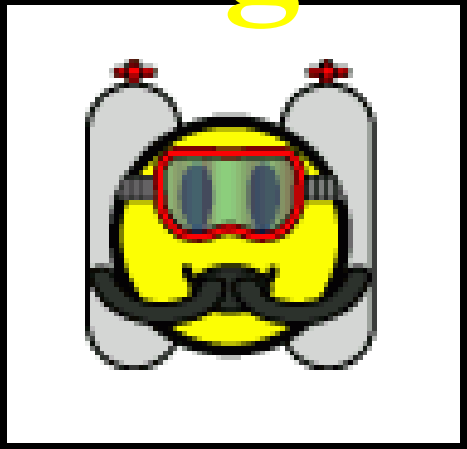
Gloves: DUI Dry ZIP Glove

Requires mating surface on dry suit wrist
Wrist seal replaced with the glove

Gloves: Viking Dry Glove

Requires mating surface on dry suit wrist
Keeps latex wrist seal intact

Weights



Standard Weight Belt

Can be harsh on zipper

Difficult to vary weights

Difficult to manage with heavy weights

Without “contraction mechanism” can slip at depth

Best used with plastic coated weights

- Lead is neurotoxin
- Sharp edges can abrade suit

LPT

Weight Belt With Pockets

Pockets filled with lead shot
Easy to vary weights
Limited capacity
Usually no “contraction mechanism”

LPT

Standard Weight Belt - Modifications

Double Buckle

Introduced for river diving

More secure than single buckle

Both open same way

Homemade Suspenders

Puts weight on shoulder

Unwise:

Difficult to ditch (3 buckles)

LPT

DUI Weight and Trim System

Weight supported by shoulders
Pull cord weight release
Worn under most BCD's
Holds maximum 40 pounds

LPT

SeaSoft Weight and Trim System

Commercial grade harness
Weight supported by shoulders
Pull cord weight release
Worn under most BCD's
Holds maximum 60 pounds

BCD– Integrated Weight System

Every vendor has different design
Need to try several

Pull-down dump desirable

Integrates buoyancy compensator and weights
Requires familiarization

Practice dropping weights on surface at end of dive

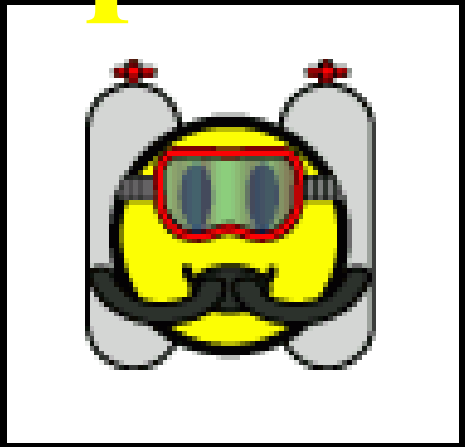
LPT

Ankle Weights

Keep feet down
Restrict air flow into feet
Generally not used by experienced dry suit divers

LPT

Options



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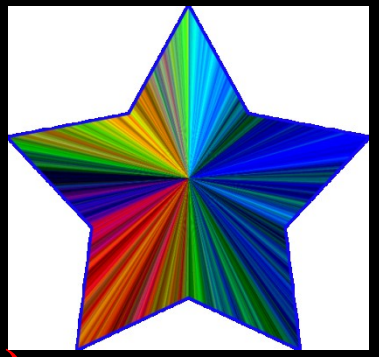
Colors



Originally Only Two Colors

Black:

Warmer (absorbs more radiation)

"Look like seal" or "look like predator"

Orange:

Bright color, easily visible

Now, multiple color options available

LPT

Fins

Fin Keepers

Insulation increases foot size
Fin pocket needs to be larger than for wet suit
Need larger, stiffer fin to overcome suit drag

Need strong strap to securely hold fin
Fins with holes not preferred (impalement risk)

Fin keepers: firmly secure fins in place
Concern that inversion will "blow away" fins

LPT

Suspenders

Secures crotch for tight fit

Holds dry suit bottoms when suit opened for surface interval

Suits manufactured after 2008 have replaceable suspenders

No suspenders sometimes awkward during surface interval

LPT

Pads & Protection

Used to reinforce (prevent abrasion)
Knee pads standard
Larger, thicker knee pads additional
Elbows typically additional

Gaitors

Chaps

Kevlar

LPT

Pockets

Variety of sizes and colors to suit needs
Knife pocket essential
Key pocket (inside suit) a good idea

Dry Suit Hangar

Hang suit by feet to facilitate drying

LPT

Dry Suit Dryer

Commercial systems
Home-made (PVC pipe and hair dryer)

LPT

Repair Kit

General: for leaks and tears

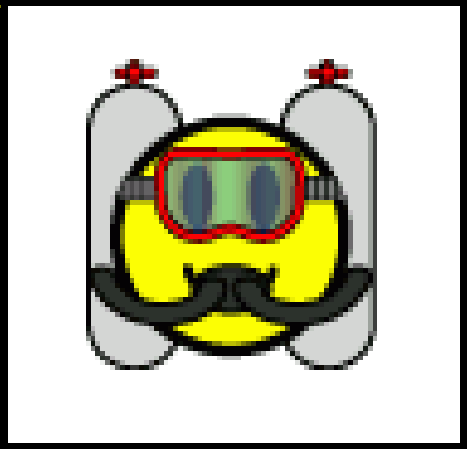
Manufacturer Specific: neck and wrist seals; zipper

LPT

Carrying Case / Bag

Want undergarments separate from suit
Typically, manufacturer dependent

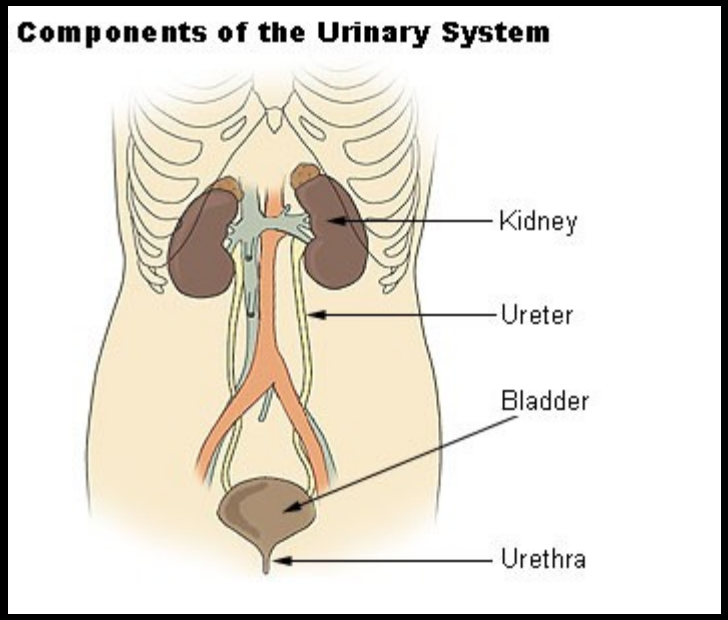
At Depth Urination



LPT

Immersion Diuresis

Combination of cold water and pressure
Moves fluid from periphery to central core
Excess Fluid in circulation removed by kidneys
Fluid moved to the bladder



LPT

Simplest Solution: Depend

Simple inexpensive urine collection

LPT

P-Valves

Diving Condom

Tube carries urine to dump valve

1-way valve dumps urine to outside environment

(failure can cause severe barotraumas)

Condom is a vasoconstrictor

Penile DCS has been reported

Needs disinfection after use

To prevent infections

LPT

She P-Valves

Allows females to plug into the P-valve

Not anatomically correct for all

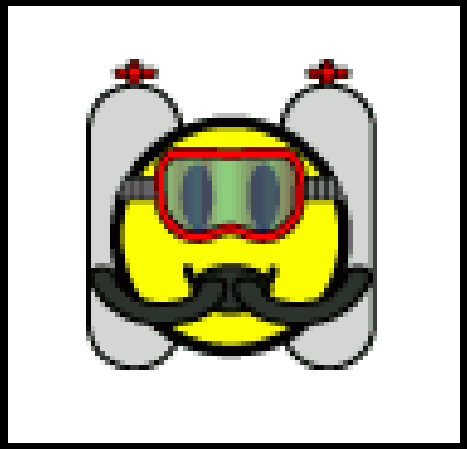
LPT

Dry Suit Urine Collection Device (DUCD)

Urine collected during dive and dumped post dive

LPT

Choosing A Suit



LPT

Choices

Consider:

Environment

Surface Exposure

Personal Comfort

Frequency of Use

Other Uses

Maintenance

Fit

Cost

Choose for YOUR needs

LPT

General Considerations

No manufacturer has “Best Suit”
For every diver, in every diving scenario

Dive shops are “franchise operations”

So, visit many shops
Examine many manufacturers
Talk to Divers
Check reviews on internet (Carefully)
If possible, dive the suit

Choose Best FOR YOU!

Whenever possible, support a local dive shop
Use Internet as “last resort”

LPT

General Considerations

For each manufacturer:

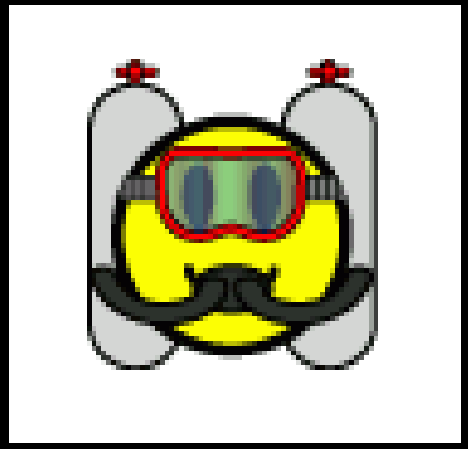
- Reputation
- Length of time in business
- Warranty
- Access to Repairs
- Are commercial grades available
  - Best for avid diver because of rugged reliability
- Instructional materials
- Repair kits
- Accessories/upgrades

Final Decision

Choose best fit and comfort
For
Your diving needs
And
Your diving budget

LPT

Leaks



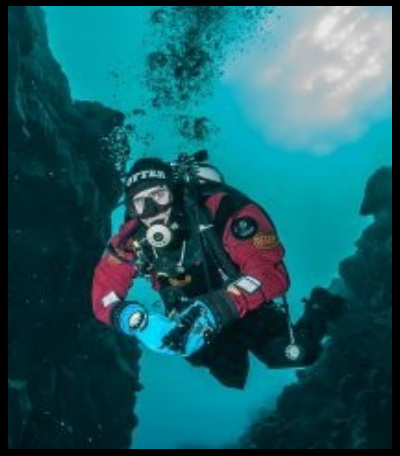
LPT

Small Amounts of Water are Common Post-dive

All suits eventually leak a bit
(Damp, OK, as long as warmth maintained)
Sealed Suit

100% humidity leads to condensation

Condensation + perspiration:
can add ~1 cup moisture into suit during dive

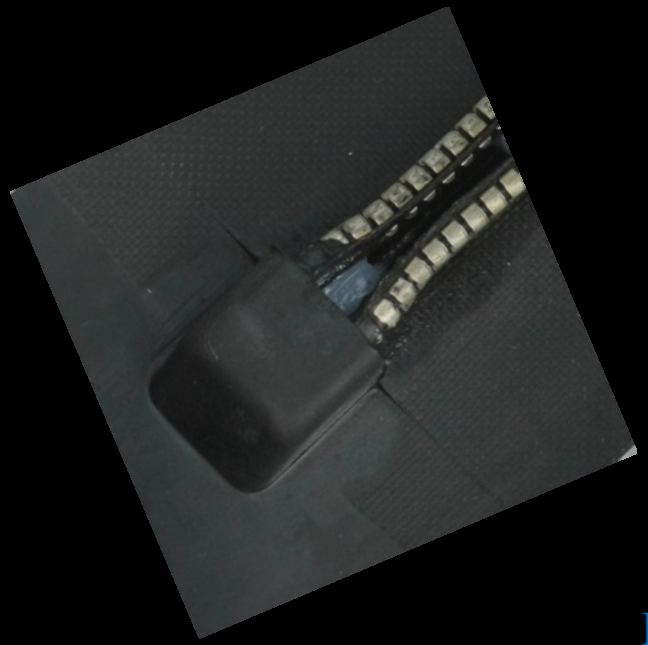


LPT

Leaks: Zipper

Most common problem: failure to completely close
Also, dirt / debris in zipper seal area

Closely with a snug pull
Clean zipper before and after every dive
Lubricate only with paraffin wax or Zip Tech
Never use silicone



LPT

Leaks: Seals

Pay particular attention to neck seal
(Want a totally smooth surface)
Rubber deteriorates with age
Latex will get gummy
Replace when gummy or torn
Lubricate with dry, unscented talc

Never use silicone

Look for:
Hair under seals
Protruding underwear
Tears and stretches

LPT

Leaks: Valve Stem

~ 75 % dry suit leaks from sharp burs on the inlet valve stem

Sharp edge cuts fabric during storage

Always store with stem covered & valve on outside of folded suit

LPT

Leaks: Outlet Valves

Improper adjustment
Dirt / sand in mechanism
Open in strong current
Worn components (seals and spring)
Rinse thoroughly after every dive
Never use silicone
Attach with aquarium cement, not aquaseal

LPT

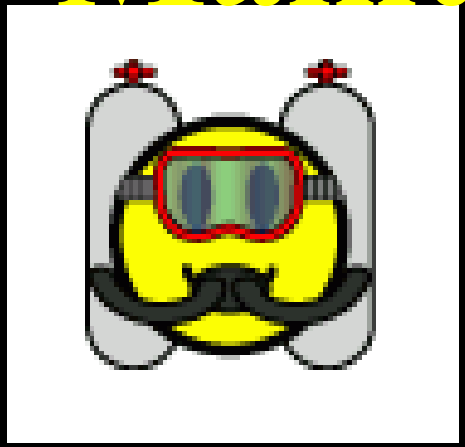
Leaks: Suit Fabric

Most common problem:
De-lamination of polyurethane coating
De-lamination of layers in trilaminate (TLS) suits

Weeping (gas cell rupture) in neoprene based suit
Or
Suit puncture, rip, or teat

LPT

Care & Maintenance



Seals

Occasionally wash with mild soap and water
Removes body oils and environmental grime

Treat with dry, unscented talc
No silicone

LPT

Dry Suit

After every day of diving:
Rinse suit (water pic) in shower
Run water through exhaust valves
Rinse closed zipper teeth with water pic
Hang by heels to dry

Avoid:
Sunlight, volatile organics, electrical motors (ozone)

Store:
Rolled or folded
Guard on inflator valve stem
Inflator valve & closed zipper on outside

LPT

Zipper

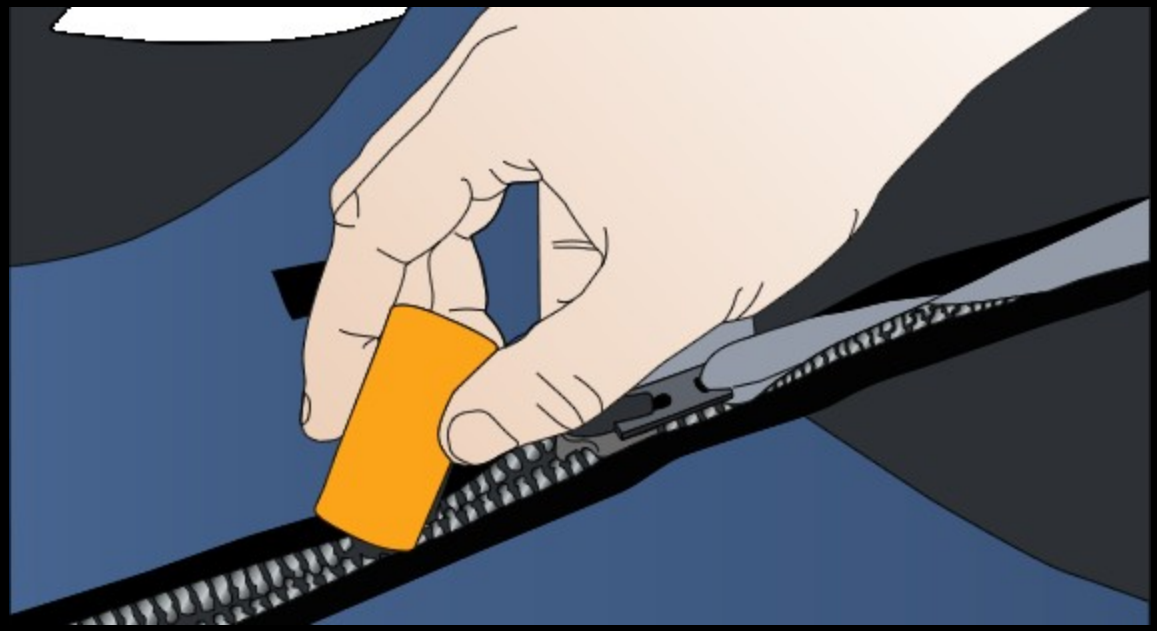
Clean with soapy water & tooth brush (Vertical strokes)

Lubricate (on outside of zipper)

pure paraffin wax, Zip Tech, or DUI Zip lube

Store with zipper closed

No silicone



LPT

Silicone Spray

Do not use any silicone product!

Loosens / degrades seals

Makes repairs impossible

LPT

Repairs

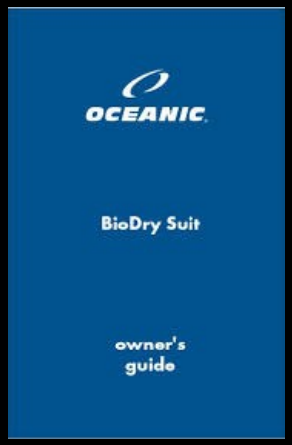
LPT

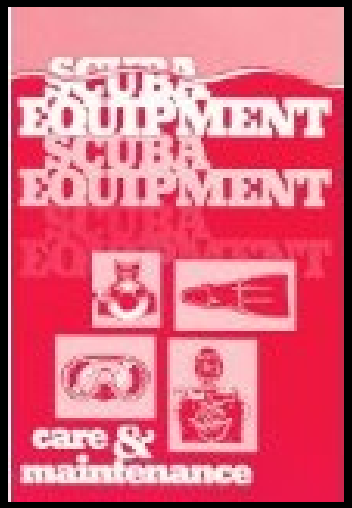
Dry Suit Repairs

Expensive, so more you can do, the less costly the diving

Info Sources:

- **Manufacturer's Manual**
- **Manufacturer's Web site**
- **U – tube videos**





LPT

Finding Leaks

1. Post-dive: feel suit for localized wet spots
Use soccer ball or balloon to fill neck; plastic cups for wrists
Inflate
Spray with soap solution
Leaking air will provide bubble source

2. Wear suit, overinflate, have someone spray suit with soap

3. Place a strong white light inside the suit in a dark room
Look for escaping light

LPT

Repairing Leaks

Use Aquaseal (1:1 with cotol) on inside of suit

Well ventilated room

Let dry for ~30 minutes, then reapply

Let dry 24 hours

Cotol
Speeds
Drying

LPT

Major Repairs

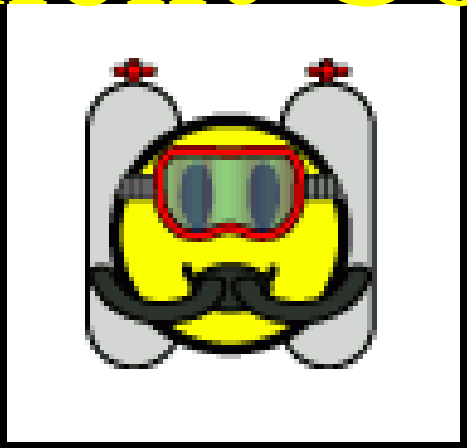
Zipper, neck seal and wrist alterations (installing ZIP)

Best done by professional

- Commercial quality repair
- Warranty
- Some (DUI) test suit integrity

LPT

Equipment Concerns



Weighting

Each equipment configuration/underwear: different weights
Standard weight belts chafe zipper
Integrated weight systems preferred
Ankle weights:
- "Training Wheels" for fearful diver
- Offset center of buoyancy / mass
- Increase leg work

Setting buoyancy:
- ~ 500 psig in cylinder
- BCD and Dry Suit empty
- Adjust weight to float at eye level
- Inhale: rise
- Exhale: sink

LPT

Buoyancy Compensator (BCD)

Always worn
Used only on the surface or emergency
Need access to inflation valve
Buoyancy at-depth controlled with suit

LPT

Hose Length

- Long enough to reach BCD and Dry Suit inflators
  - Without strain on hose or valve
  - Best not to cross zipper
- Short enough to avoid entanglement loops
  - Often requires custom length hoses

See anything that needs improvement?

LPT

See anything that needs improvement?

Mask on forehead
- easily lost
- picks up body oil; promotes fogging
- some consider it sign of stress

Dry suit hose crosses zipper
- potential premature wearing

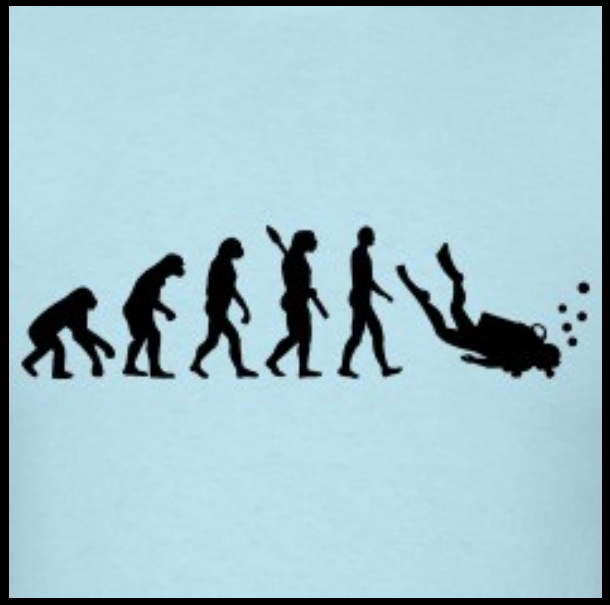
Weight belt not trimmed
- potential loss of weights from snag

Weight belt crosses zipper
- potential premature wearing

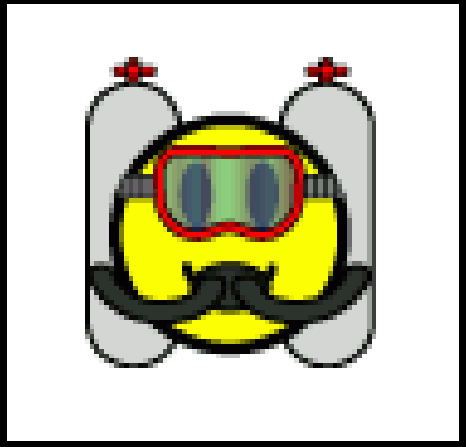
Probably should be wearing gloves

2 nd regulator may not be secured
- (Not in “golden triangle”)

LPT



Diving Techniques



LPT

Pre-Dive Check

Assemble all gear before putting on dry suit
(Limit overheating)
Lubricate zipper
Check suit for integrity

LPT

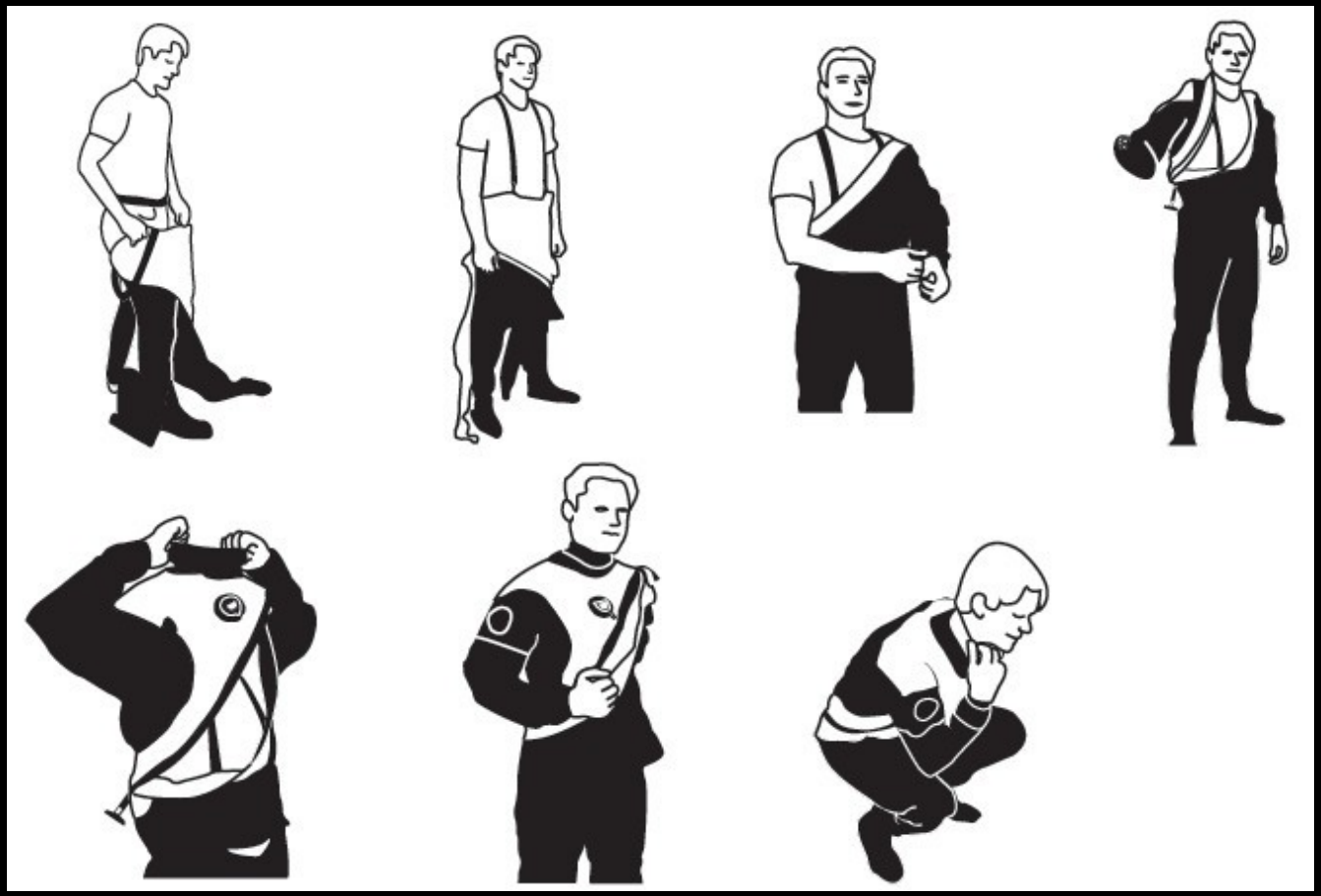
Donning Underwear

Best done in a seated position
Should be on dry ground to protect booties
Needs to be free of seals and zipper

LPT

Donning Dry Suit

Follow manufacturer's recommendation for your style zipper



Remember to fully close zipper

LPT

Closing zipper

Back Zipper: Best to have another close

Remember to fully close zipper

LPT

Check Seals Before Entering Water

Look for anything (usually underwear) that interferes with seal
Seals should be smooth with no folds

LPT

Pre-Dive Buddy Check

SEABAG:

S = Signals

E = Emergency procedures (air sharing)

A = Activity of dive

B = Buoyancy Control check

A = Air On

G= Go Diving!

LPT

Entering Water

Dry Suit: deflated as much as possible
BCD inflated to maintain flotation
Final check with buddy
To descend: vent BCD

LPT

Entering Water

Without BCD

Must overinflate suit (stresses seals and zipper)

Difficult to maintain vertical orientation for descent

Many Michigan deaths have been attributed to diving a dry suit without BCD

Diving a dry suit without BCD is considered "death seeking behavior"

LPT

Descent

Control descent with small bursts of gas to inflate dry suit

Only enough to offset squeeze

should feel compression ion legs in vertical position

want to minimize amount of air (moving center of buoyancy)

Close (or ½ max) auto exhaust

Descend in feet first vertical position

best visibility of site and buddy

best position to equalize ear pressure

"clear" with Frenzel

LPT

At Depth

Should feel suit hugging the body … no moving gas pockets

Common Error: adding too much gas to suit

LPT

Ascent

Manual: lift arm; press vent as needed to release expanding gas
Auto: lift arm; open valve; hold arm level with shoulder

Manual

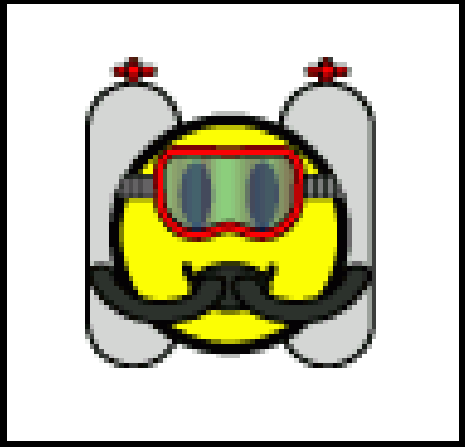
Auto

LPT

Post-Dive

Remove dive gear
Immediately cap inlet valves
Brush away dirt
Store

Potential Problems



LPT

Potential Problems

Problems should be mere inconveniences, not life threats

NASA: Practice Prevents Piss-Poor Performance

LPT

Flooded Suit

Can be from rip, tear or exhaust valve failure

Typically, little water entry ‘cause suit is sealed system

Immediate problem is hypothermia

Can easily ascend to surface

Problem is exiting the water with excess weight

- Non-synthetic undergarments absorb water weight
- Additional mass from water in suit

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Inverted Position

"Finger walking" Desirable low impact technique
creates little silt
saves air

Recovery:
Push forward with hands
Creates horizontal swimming position

Air inside lower leg makes this technique easy

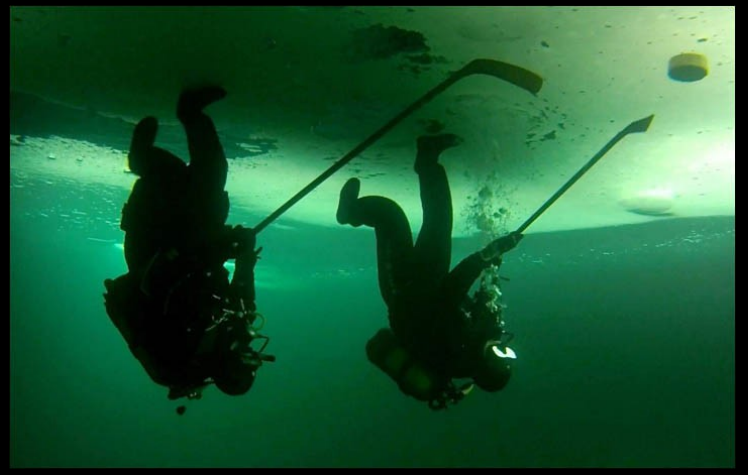
Inverted Position – At Depth

Very rare in properly weighted/diver

Drive hard downward … then arch back as much as possible
This will change orientation to vertical position
Vent air

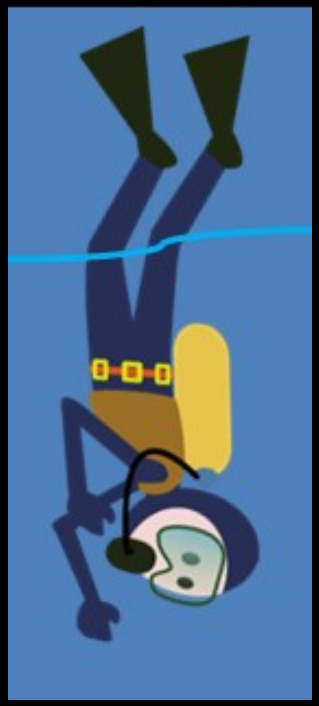
Or

Drive hard downward
Tuck and roll forward into vertical position
Vent excess air



LPT

Inverted Position – On Surface



Can be lethal, especially if regulator has been lost

Problem: feet out of water … no downward driving force
Solution:
First, try to tuck and roll
Once head above feet, air moves to shoulders
Over inflate suit (while exhaling) … drives shoulders to surface
Last resort, drop weights, add air to bcd
Once feet in water, you have propulsion to move forward

If face down, can try crossing legs and rolling hard

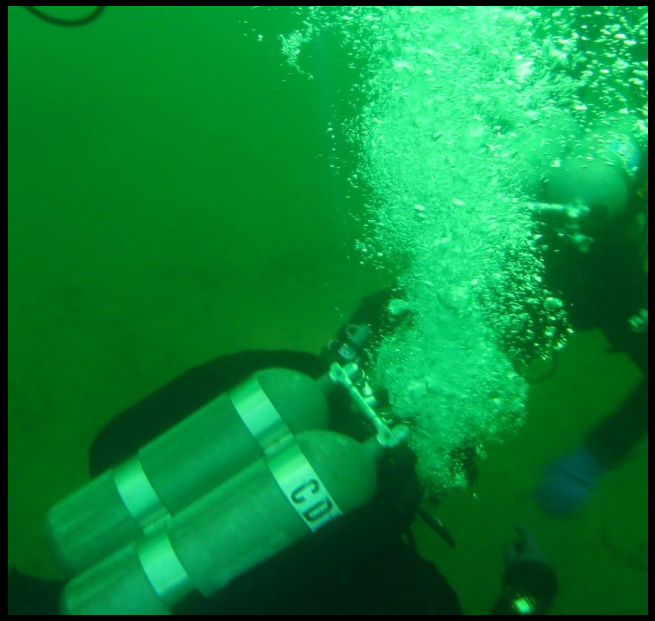
Mi divers have been found in the St. Clair River
drifting inverted, regulator dangling, air in cylinders

LPT

Stuck Inflator Valve

Classic solution: Unhook inflator hose; vent air from dump valve
Problem: may not work … on surface before you have time to un-hook

Runaway valve generates rush of air … sounds like a freight train
Lay on back (create more drag) with arms and legs spread
Relax, breathe normally and enjoy the ride
Once in position, try to remove inflator hose with dominant hand



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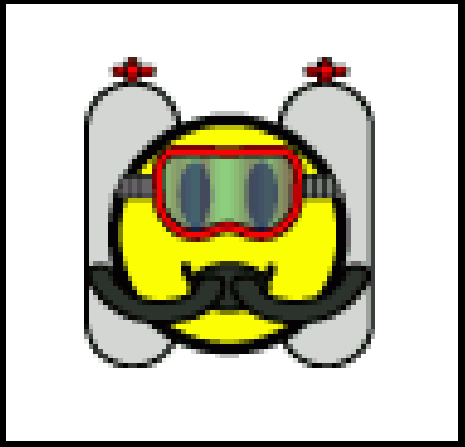
Open Water Exercises



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Open Water Skills

Day 1 **Dive 1**

Establish Correct Buoyancy
With all air removed from BC and suit, should float at eye level
Rise and fall with inhalation
Redo at end of dive
Practice ascent and descent along vertical ascent lines
While remaining stationary in mid water, assemble H shaped puzzle
Swim across variable terrain to practice buoyancy controls

Dive 2

Practice finger walking
Practice recovery from inverted (at depth and on surface)
Practice flare and dump for free flow simulation
Swim across variable terrain to practice buoyancy controls

Day 2 **Dive 3**

Practice flooded suit
(Simulate with added weight)
Remove and replace BCD /scuba
Swim across variable terrain to practice buoyancy controls

Dive 4

Connect & disconnect inflator hose
Swim across variable terrain to practice buoyancy controls

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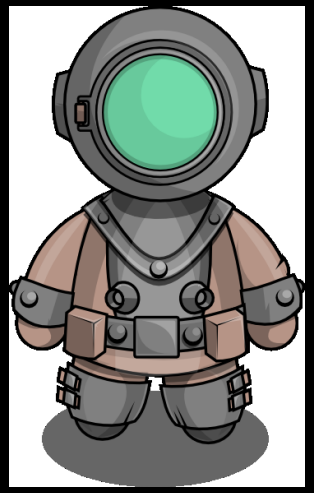
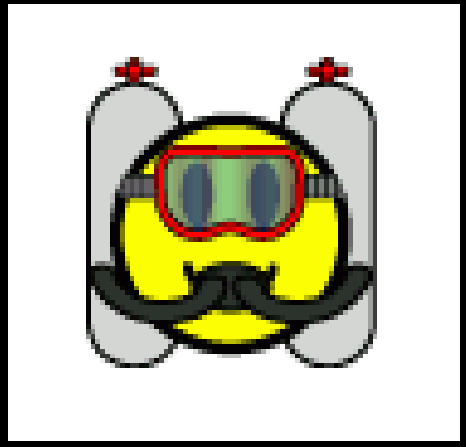


Open Water Training Sites



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Ohio Training Sites

Site depends on:

- **Local Events**
- **Weather**
- **Visibility**
- **Diving Mission**

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PORTAGE QUARRY RECREATION CLUB INC.

Bowling Green, Ohio

12701 S. Dixie Highway (Rte 25)
Bowling Green, OH 43401
(419) 352-9203

www.portagequarry.com

Take Ramp onto US-23	0.6 mi
Road name changes to I-94 Branch [US-23]	1.1 mi
At exit 35, road name changes to US-23	31.3 mi
Road name changes to US-223 [US-23]	7.1 mi
Entering Ohio	
Road name changes to US-23	0.8 mi
Road name changes to I-475 [US-23]	12.9 mi
At exit 1A, take Ramp (RIGHT) onto I-75	12.5 mi
At exit 179, turn RIGHT onto Ramp	0.3 mi
Take Ramp (RIGHT) onto US-6 [W US-6]	1.1 mi
At exit 65, keep RIGHT onto Ramp	0.2 mi
Road name changes to Local road(s)	21 yds
Turn LEFT (South) onto OH-25 [Dixie Hwy S]	0.9 mi

~ 70 miles ~ 61 minutes

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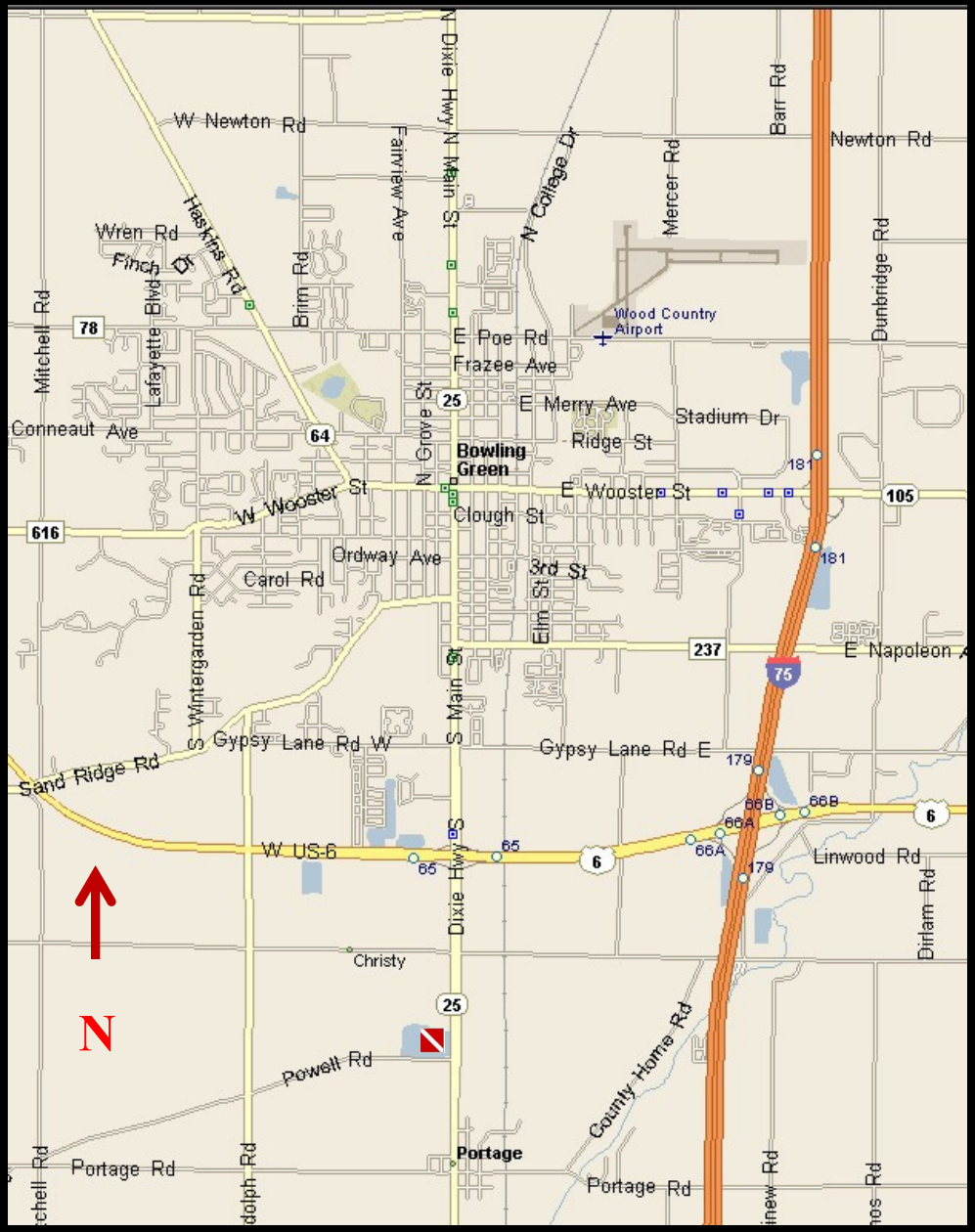
PORTAGE QUARRY RECREATION CLUB INC.

Local Area



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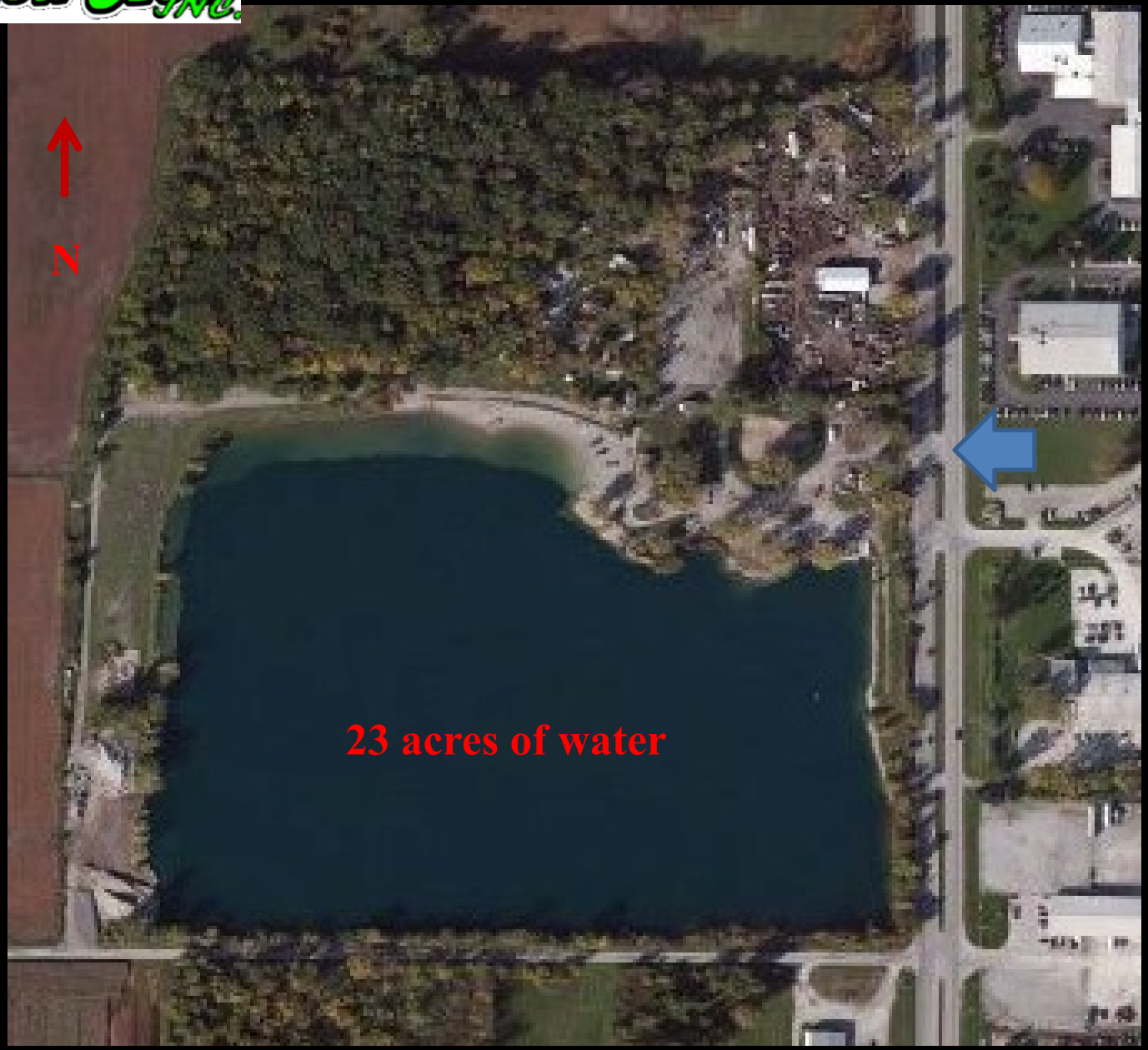
PORTAGE QUARRY RECREATION CLUB INC.

Aerial View



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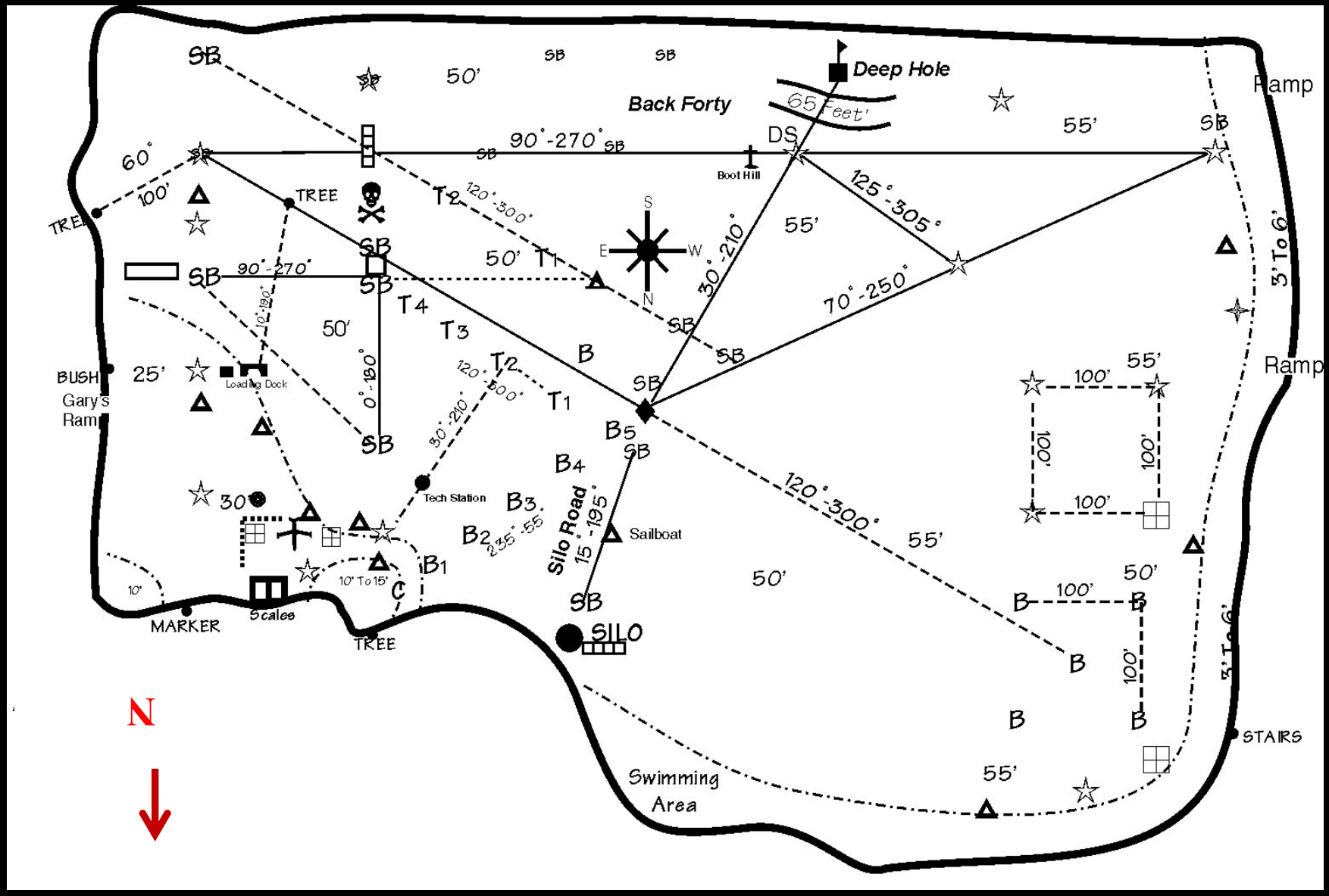
Underwater Schematic



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White Star Quarry

901 S. Main
Gibsonburg, OH 48431
(419) 637-3483

www.whitestarquarry.com

Most planners give this route
(details on next page)
Avoids toll road (US 80)

But, US 20 is nationally known
For its **Speed Traps**
(especially Woodville)

LPT

White Star Quarry

901 S. Main
Gibsonburg, OH 48431
(419) 637-3483

www.whitestarquarry.com

Take Ramp onto US-23	
Road name changes to I-94 Branch [US-23]	1.1 mi
At exit 35, road name changes to US-23	31.3 mi
Road name changes to US-223 [US-23]	7.1 mi
Entering Ohio	
Road name changes to US-23	0.8 mi
Road name changes to I-475 [US-23]	12.9 mi
At exit 1A, take Ramp (LEFT) onto I-75 [US-23]	1.6 mi
At exit 193, turn RIGHT onto Ramp	0.3 mi
Turn RIGHT (East) onto US-20 [US-23]	16.7 mi
Turn RIGHT (South) onto OH-300 [State Route 300]	2.3 mi
Keep STRAIGHT onto OH-300 [N Main St]	1.0 mi
Keep STRAIGHT onto OH-300 [S Main St]	0.8 mi

~78miles ~ 73 minutes

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White Star Quarry

Alternative Route 1 From Ann Arbor Avoids Speed Traps Route

Take Ramp onto US-23	0.6 mi
Road name changes to I-94 Branch [US-23]	1.1 mi
At exit 35, road name changes to US-23	31.3 mi
Road name changes to US-223 [US-23]	7.1 mi
Entering Ohio	
Road name changes to US-23	0.8 mi
Road name changes to I-475 [US-23]	6.8 mi
At exit 6, turn RIGHT onto Ramp	0.3 mi
Turn LEFT (East) onto CR-91 [Salisbury Rd]	0.1 mi
Road name changes to (W) Dussel Dr	1.4 mi
Turn LEFT (North) onto US-20 [Reynolds Rd]	0.1 mi
Toll road Keep RIGHT onto Ramp	0.6 mi
Toll road Take Ramp (RIGHT) onto I-80 [I-90]	22.1 mi
Toll road At 81, turn off onto Ramp	0.9 mi
Turn LEFT (South) onto OH-51 [State Route 51]	2.2 mi
Turn RIGHT (West) onto US-20 [W State Route 20]	1.1 mi
Turn LEFT (South) onto OH-300	10 yds
Keep STRAIGHT onto OH-300 [State Route 300]	2.3 mi
Keep STRAIGHT onto OH-300 [N Main St]	1.0 mi
Keep STRAIGHT onto OH-300 [S Main St]	0.8 mi

82 miles ~ 76 minutes Toll $1.50

LPT

White Star Quarry

Alternative Route 2 From Ann Arbor
Avoids Speed Traps Route

Take Ramp onto US-23	0.6 mi
Road name changes to I-94 Branch [US-23]	1.1 mi
At exit 35, road name changes to US-23	31.3 mi
Road name changes to US-223 [US-23]	7.1 mi
Entering Ohio	
Road name changes to US-23	0.3 mi
Take Ramp (LEFT) onto I-475	6.6 mi
At exit 20B, turn LEFT onto Ramp	0.3 mi
Take Ramp (RIGHT) onto I-75	3.2 mi
At 208, take Ramp onto I-280	12.5 mi
Toll road At 1A, turn RIGHT onto Ramp	0.6 mi
Toll road Take Ramp (RIGHT) onto I-80 [I-90]	9.8 mi
Toll road At exit 81, turn RIGHT onto Ramp	0.9 mi
Turn LEFT (South) onto OH-51 [State Route 51]	2.2 mi
At Busy Corners, stay on OH-51 [State Route 51] (South)	43 yds
Turn RIGHT (West) onto US-20 [W State Route 20]	1.1 mi
Turn LEFT (South) onto OH-300	10 yds
Keep STRAIGHT onto OH-300 [State Route 300]	2.3 mi
Keep STRAIGHT onto OH-300 [N Main St]	1.0 mi
Keep STRAIGHT onto OH-300 [S Main St]	0.8 mi

82 miles ~ 78 minutes Toll $0.75

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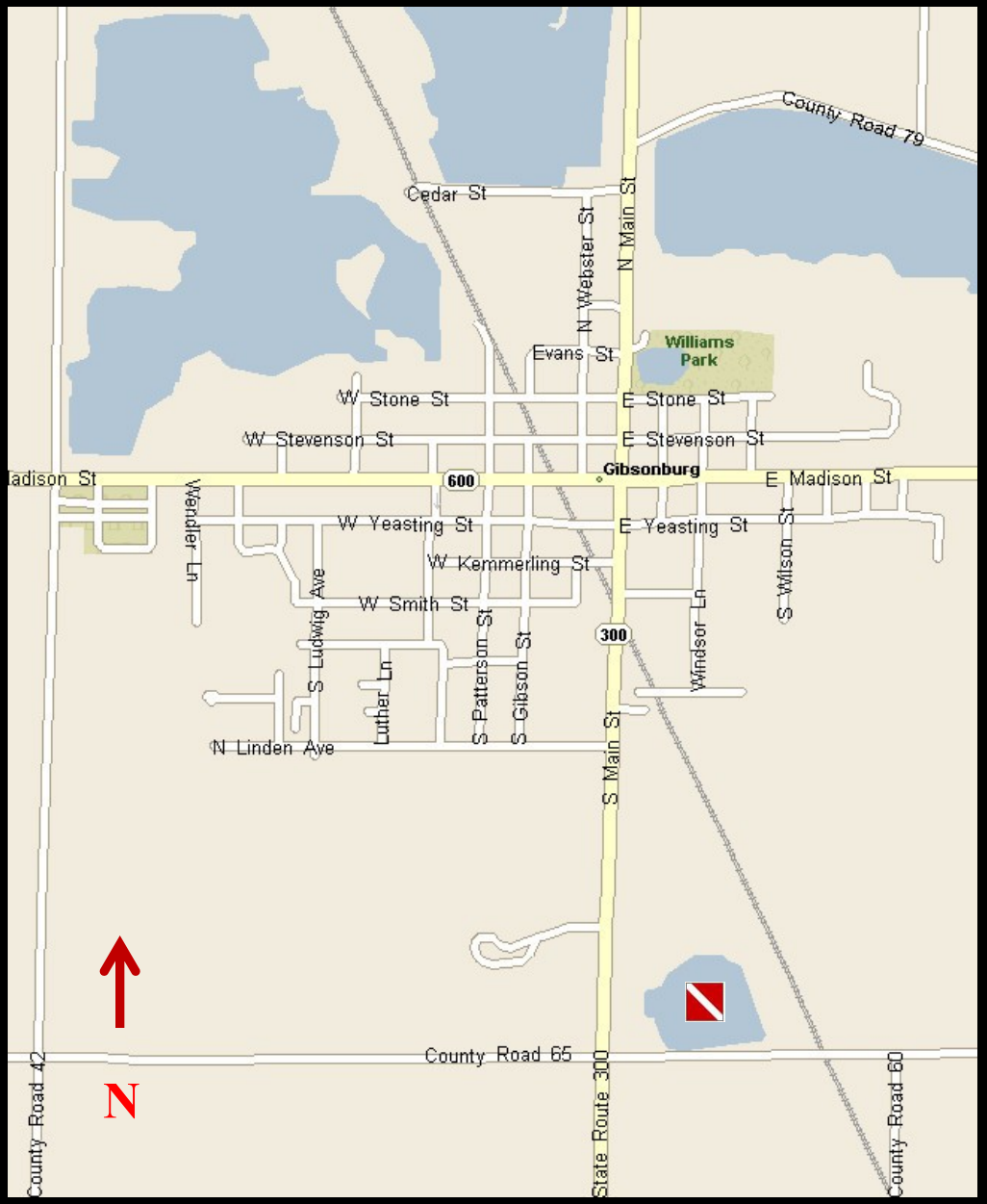
White Star Quarry

Local Area

Tower @ US 20 & OH 300



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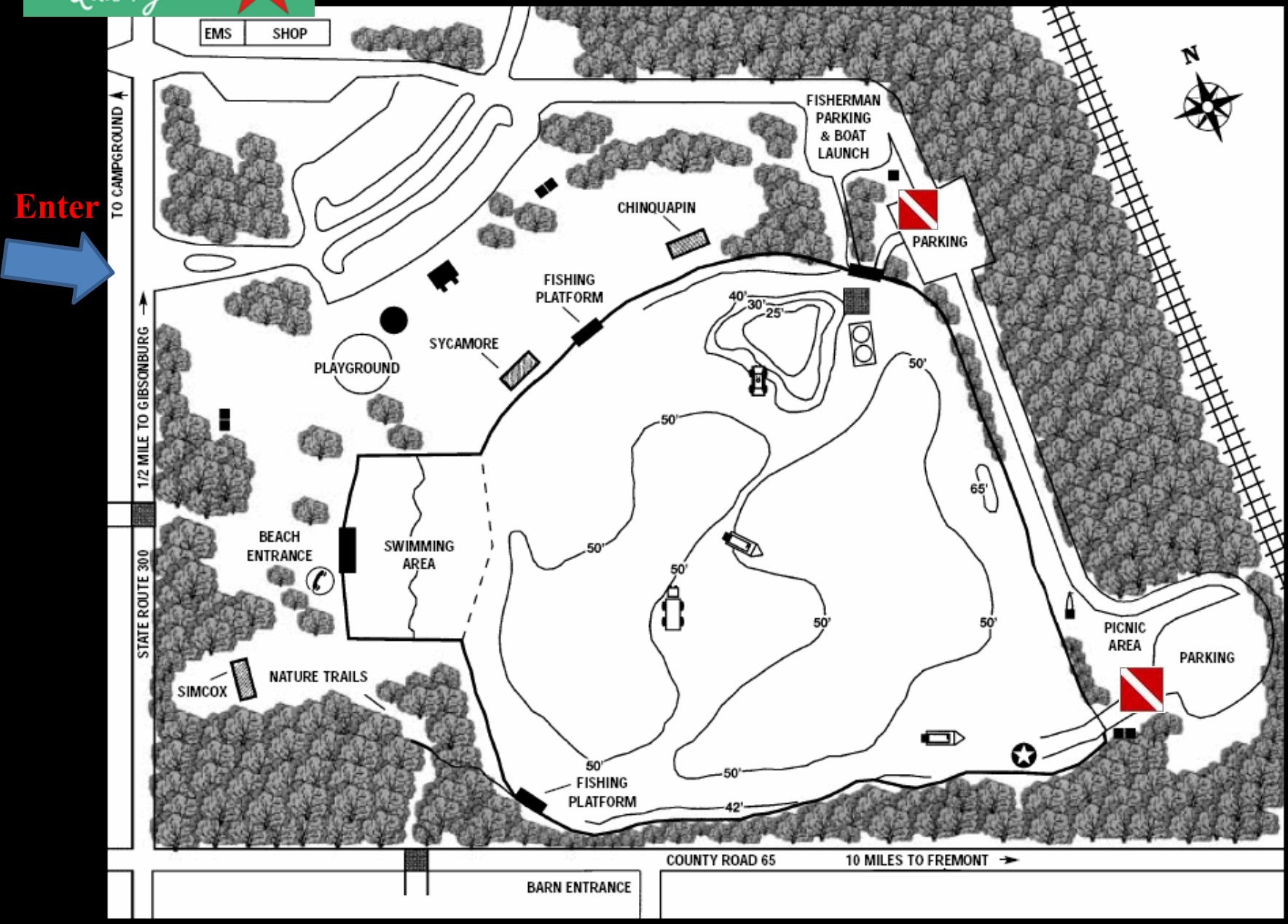
Aerial View

LPT

Schematic



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Gilboa, Ohio

3763 Old State Rte 224
Gilboa, OH 45875
(419) 456-3300
www.divegilboa.com

Take Ramp onto US-23	0.6 mi
Road name changes to I-94 Branch [US-23]	1.1 mi
At exit 35, road name changes to US-23	31.3 mi
Road name changes to US-223 [US-23]	7.1 mi
Entering Ohio	
Road name changes to US-23	0.8 mi
Road name changes to I-475 [US-23]	12.9 mi
At exit 1A, take Ramp (RIGHT) onto I-75	33.2 mi
At exit 159, turn RIGHT onto Ramp	0.2 mi
Turn RIGHT (West) onto US-224 [OH-15]	14.1 mi
Turn LEFT (South) onto Franklin St	0.4 mi
Turn RIGHT (West) onto Main St	153 yds
Road name changes to Old Oh-224 [Old State Route 224]	0.6 mi

Turn Left at Bull

~ 105 miles ~ 120 minutes

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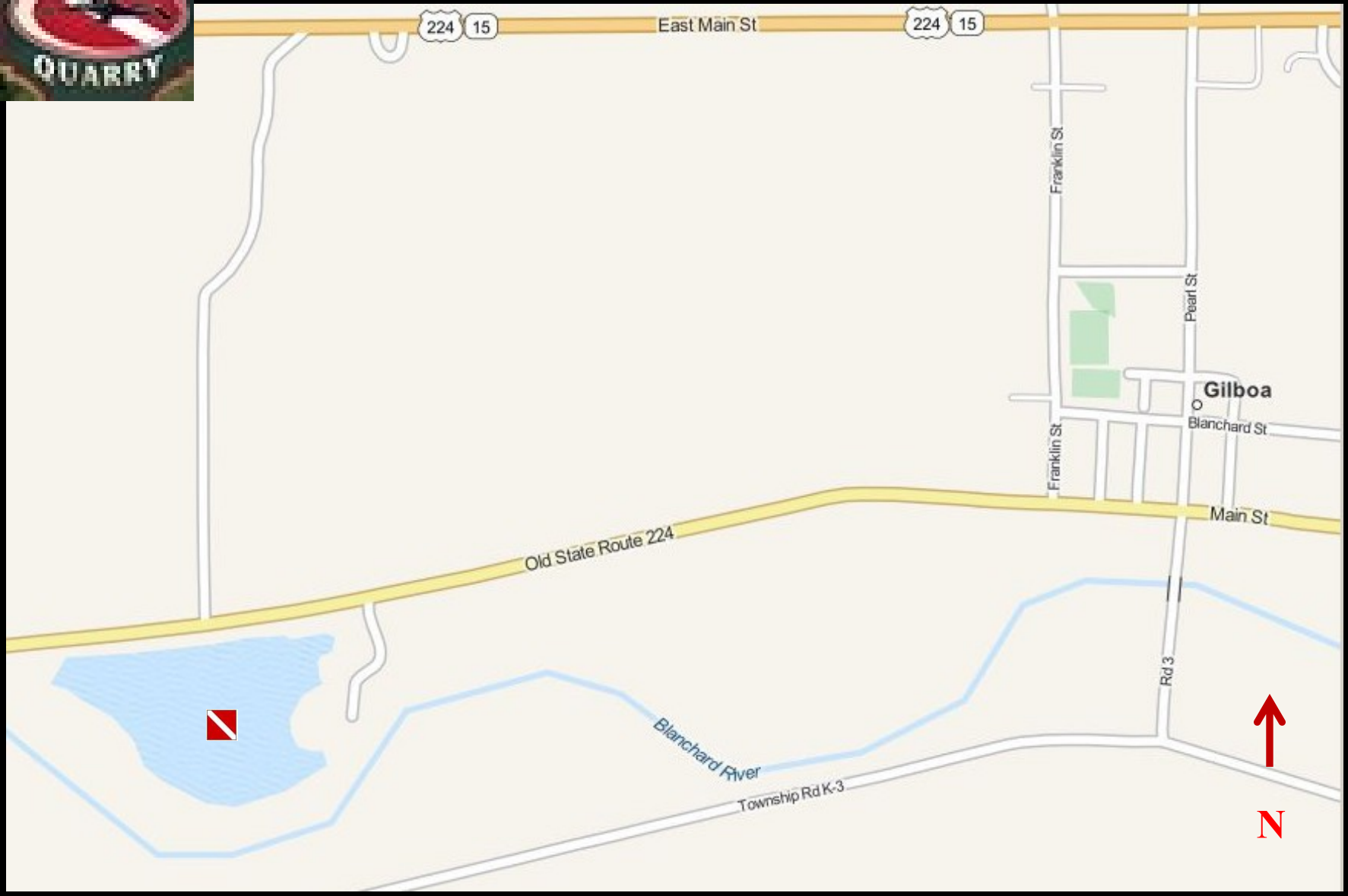
Local Area



LPT

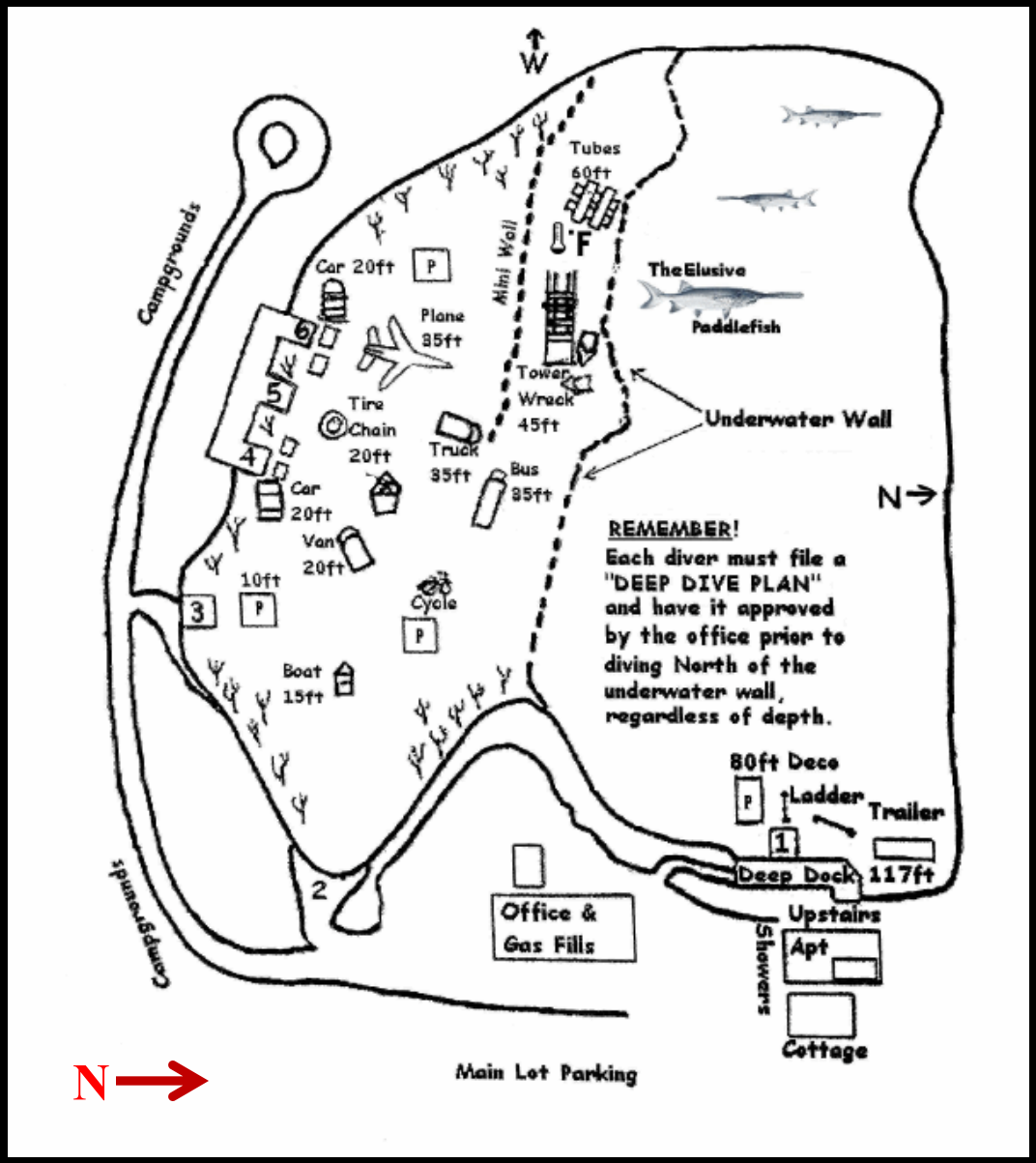
Aerial View

LPT

Schematic

Entrance

Deep Diving Platform



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Bottom Layout

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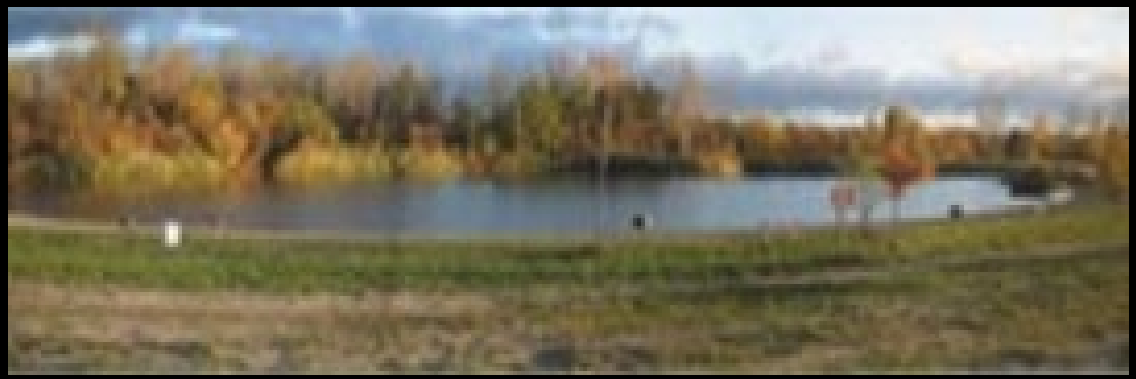
Spring Mill Pond

Island Lake Park Entrance
6301 Kensington Rd
Brighton MI, 48116
(810) 229-7067

Take Ramp onto US-23	17.9 mi
texit 55, keep RIGHT onto Ramp	0.3 mi
Turn RIGHT (East) onto Silver Lake Rd	1.2 mi
Turn LEFT (North) onto Stoney Creek Dr	1.3 mi
Turn RIGHT (East) onto McCabe Rd	131 yds
Turn LEFT (North) onto Local road(s)	0.4 mi



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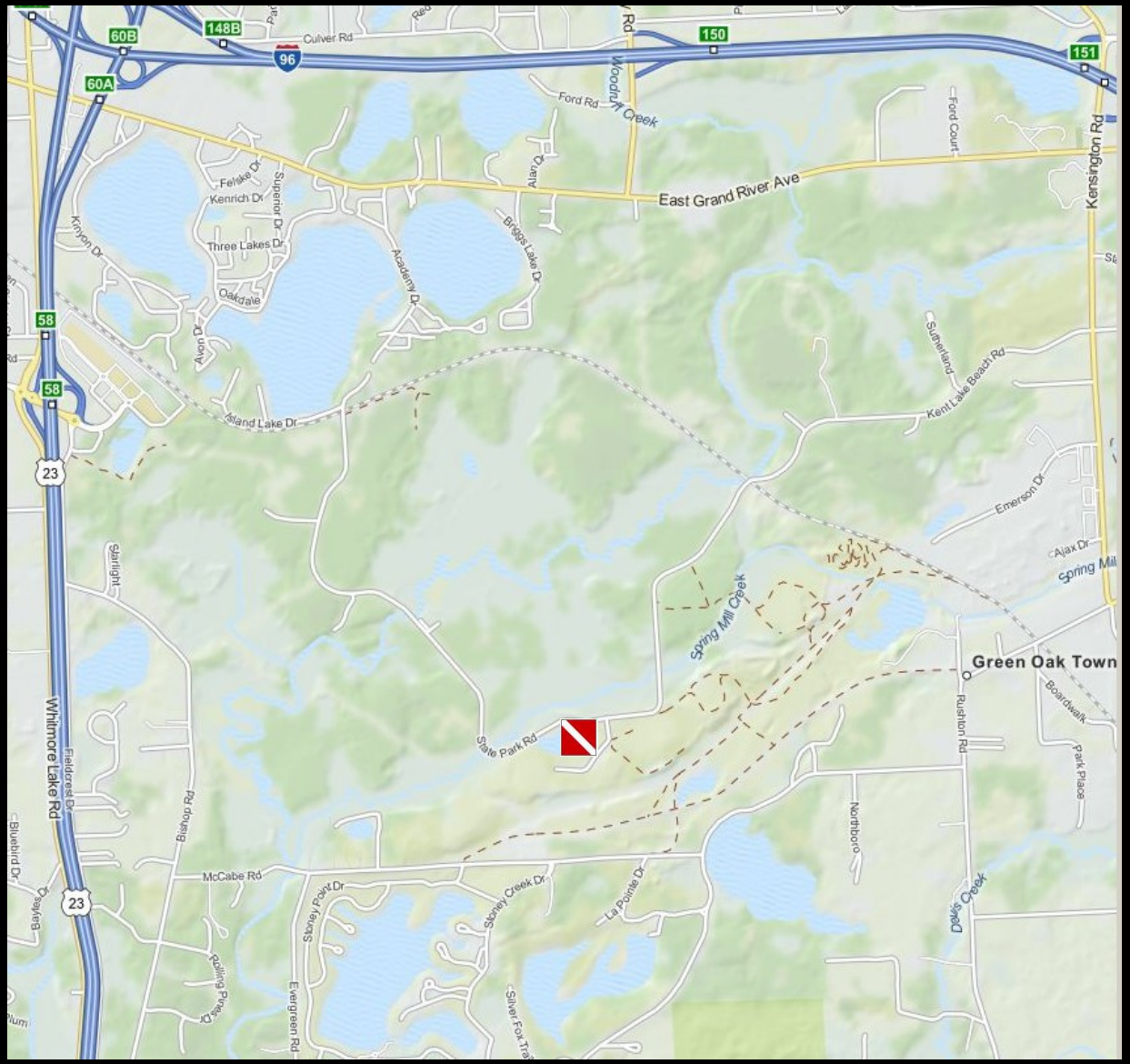
Local Area

Entrance



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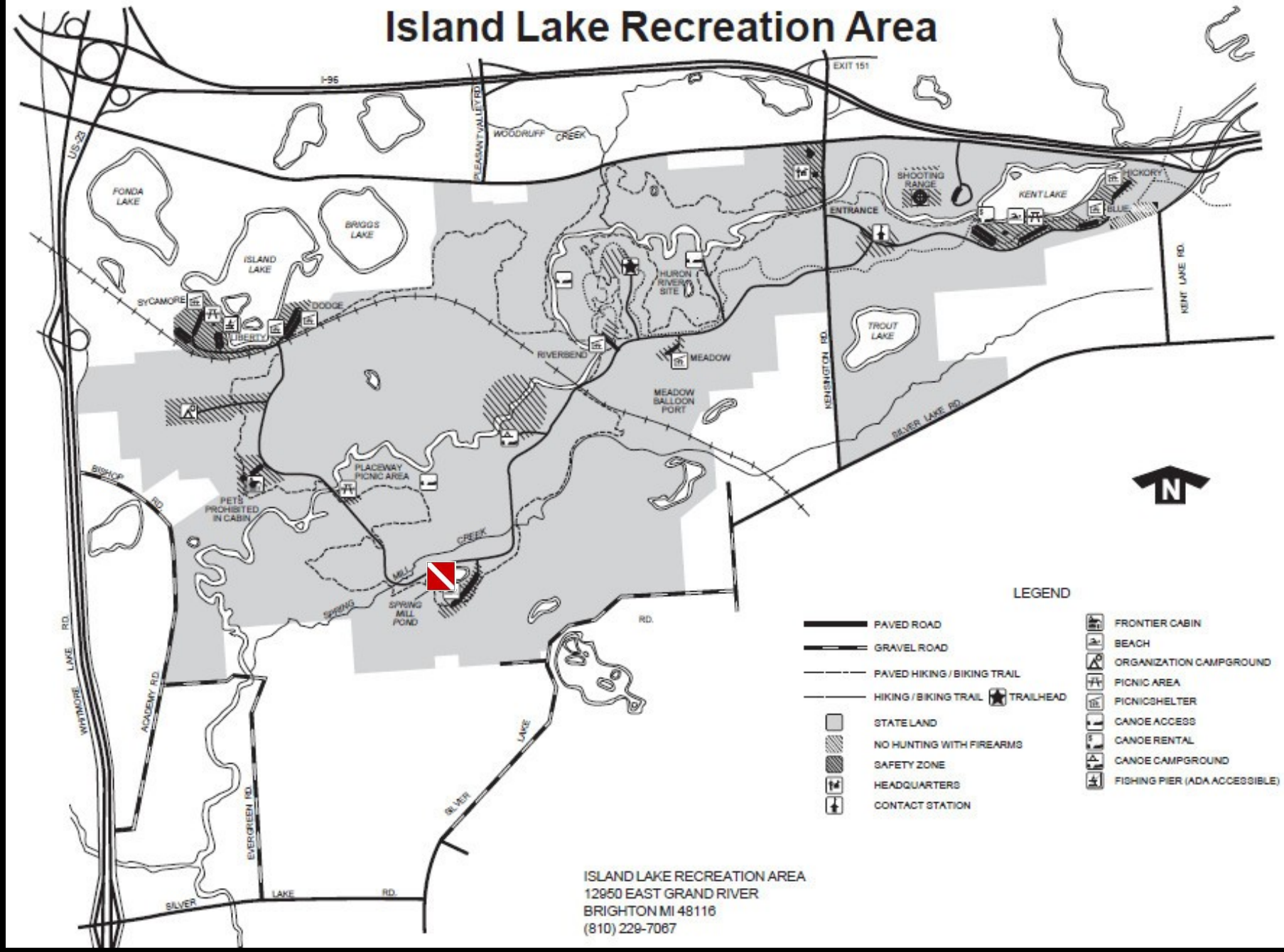
Island Lake Recreation Area



ISLAND LAKE RECREATION AREA
12950 EAST GRAND RIVER
BRIGHTON MI 48116
(810) 229-7067

Aerial View

LPT

Rally Point: My Car (Black Hyundai Tucson GLS)

LPT


Dive Long
And
Prosper!