# **Global Warming Update**

(and its effects on Stormwater)



"And so, while the end-of-the-world scenario will be rife with unimaginable horrors, we believe that the pre-end period will be filled with unprecedented opportunities for profit."

## Managing Grief

#### Kübler-Ross Grief Cycle



### Causes

Every hour of every day:

- 3.7 million barrels of oil are extracted
- 932,000 tons of coal are mined
- 395 million cubic meters of natural gas (methane) are removed
- 4.1 million tons of carbon dioxide (CO2) are emitted
- 9,300 more people inhabit the Earth



Greenhouse gases (CO2, methane, N2O, others) are trapping the suns heat. There is no controversy or debate. The earth is warming and human activities are the cause.



# Atmospheric CO2 Over the Millenia



- CO2 trapped in ice bubbles were used to generate these data
- Past 650,000 years, the range was 180 300 ppm
- Periods of low CO2 were ice ages, high CO2 were warm periods
- Current CO2 level is 409 ppm and rising

### CO2 at Mauna Loa, Hawaii (1958 – present)



### April, 2016 at Mauna Loa



### Effects on Global Temperature

Monthly Global Average Temperature in December





Anomalies are deviation from baseline (1981-2010 Average). The black thin line indicates surface temperature anomaly of each year. The blue line indicates their 5-year running mean. The red line indicates the long-term linear trend.

### Is Global Warming Going Exponential?

- Fourteen of the fifteen hottest years since 2001.
- Recent data for global monthly temperature:
  - December 2015 = 1.10°C (new record)
  - January 2016 = 1.14°C (new record)
  - February 2016 = 1.50°C (new record)



- 2.0°C is the targeted warming for 2100 set in Paris last December (aspirational goal of 1.5°C).
- Above 2°C, global warming is viewed as potentially "dangerous" for humanity.

# **Polar Amplification**

- Poles have warmed as much as 4 – 6 °C
- Very different picture in Arctic vs. Antarctic regarding effects



### Arctic vs. Antarctic

Ocean surrounded by land.



Land surrounded by ocean.

## Arctic Sea Ice

- 1980s, 90s and 00s average sea ice extent decreasing
- 2012 was a record year for sea ice decline
- 2016 is tracking to be well below 2012



- No end to this decline
  Is in sight or even conceivable as long as greenhouse gas emissions continue unabated
- Why do we care about Arctic sea ice?

## Arctic Sea Ice Loss

#### Some consequences of less sea ice

- 1. Smaller area for reflection of sun's rays (albedo effect)
- 2. More solar heating of the Arctic Ocean
- 3. More heat  $\rightarrow$  less ice  $\rightarrow$  less reflection  $\rightarrow$  more heating  $\rightarrow \rightarrow \rightarrow$  runaway heating
- 4. Methane ice (hydrates) in Arctic Ocean sediments are exposed to heat and are released.



# Methane Ice (Hydrates)

 Methane (a.k.a., natural gas, CH4) occurs in sediments as plants and animals decompose, and can form ice.



- Vast amounts of hydrates exist in the Arctic; several times more than all the oil, coal and gas ever consumed.
- Main location on Arctic Ocean continental shelves
- Hydrates return to a gaseous state as they warm, releasing methane into the atmosphere.
- Atmospheric methane is 80-fold more effective at trapping heat than CO2 in the first 10 years after release.
- Over time it breaks down into CO2, which then stays in the atmosphere for hundreds of years.

# Outlook

- GG levels continue to rise as global populations increase and rates of emissions rise.
- Temperatures continue to rise, perhaps exponentially
- Sea level rise from thermal expansion and melting an unstoppable process that eats away at coastlines → uninhabitable → mass human migrations
  - Early 1900s = less than 1 mm/year sea level rise
  - 1950s = 2 mm/year
  - Late 1900s = 2.9 mm/year
  - Present = 3.4 mm/year



# **Outlook (continued)**

- Isle de St. Charles, LA was just moved and is the first US example of an abandoned town due to GW sea level rise.
- Ocean acidification carbonic acid in the ocean leads to the extinction of species. Phytoplankton, responsible for much of the O2 we breathe, are in decline. Fish and coral are in decline.
- Freshwater from Greenland is colliding with the Gulfstream and forming a dipole, generating severe weather in northern Europe.
- Arctic Polar Jetstream has changed its path to one that is frequently an oscillating mess allowing heat into the Arctic.
- Permafrost is melting (20% of N. America is permafrost land).
- Gulfstream is slowing down.
- "6<sup>th</sup> Great Extinction" underway?
- The complete list is very much longer...



# **Outlook (Stormwater)**

Observed U.S. Trend in Heavy Precipitation



# **Outlook (Stormwater)**

- More heat in the atmosphere allows for more water vapor in clouds and more energy overall in storms.
- Unnamed storms can have hurricane force winds and major amounts of rainfall.
- More storms, with ever increasing severity affects stormwater runoff. More water can fall in shorter periods of time.
- "Traditional" backward-looking (historical) calculations for 10, 50, 100 year rainfalls cast into doubt.
- These rainfall projections are used for municipal planning.

# The Good News

- If storm chasing is your favorite pastime...
- Welcoming climate refugees into your community will improve diversity...
- You never really liked animals much anyway...
- Plants grow better with more CO2 in the air

