



## Constructed Wetlands

- Goal:
  - To provide a brief introduction to Constructed Wetlands (CW), and how they fit within Idaho's regulatory structure
    - CW acceptable configurations
    - Discuss some misconceptions about their abilities
    - Present Rule:
      - Requirements
      - Exemptions
- This presentation will NOT discuss design criteria

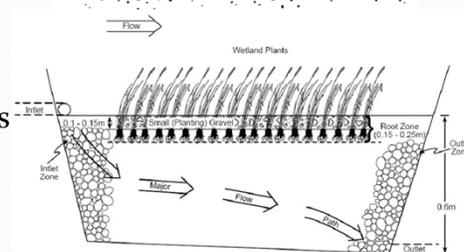
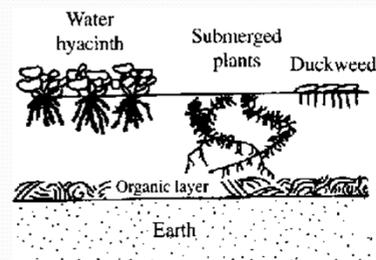
## Constructed Wetlands

- CW: an artificial wastewater treatment system
  - Typically less than 3 ft (1 m) deep
  - Planted with aquatic plants
  - May contain an inert, porous media, or
  - May provide a free water surface
  - Lined
    - Synthetic
    - Engineered Soil
- Used world wide (ca 2005)
  - Germany ~ 50,000
  - N. America ~ 8,000



## Constructed Wetlands

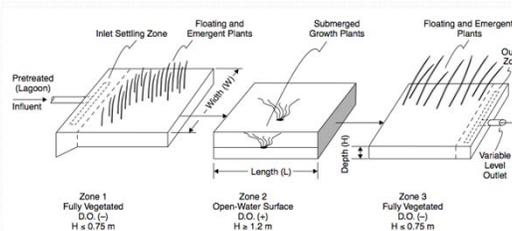
- DEQ accepts 2 forms of CW for treating municipal wastewater:
  - Free Water Surface (FWS), also known as surface flow wetlands
- Vegetated Submerged Bed (VSB), also known as subsurface flow wetlands



## Constructed Wetlands

• A FWS is typically composed of the following component sections.

- Pretreatment
- Inlet
- Fully vegetated zones
- Open water zones
- Outlet
- Water elevation control structure
- Disinfection sys if required
- Effluent Dispersal method
  - Surface water discharge
  - Subsurface dispersal
  - Land application



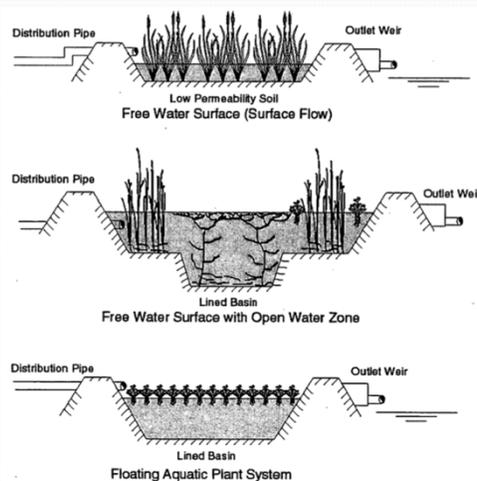
## Constructed Wetlands

• FWS Configurations

- Emergent vegetation
- Open water zone
- Floating aquatic plant

• Thorough source for design, construction, & O&M info:

- *Free Water Surface Wetlands for Wastewater Treatment, A Technology Assessment* (EPA 832-S-99-002)



## Constructed Wetlands

- FWS data

| Constituent                     | Influent (kg/ha-d) |      |     | Influent (mg/L) |        |         | Effluent (mg/L) |       |       |
|---------------------------------|--------------------|------|-----|-----------------|--------|---------|-----------------|-------|-------|
|                                 | Min                | Mean | Max | Min             | Mean   | Max     | Min             | Mean  | Max   |
| Biological Oxygen Demand (BOD)  | 0.04               | 31   | 183 | 1.7             | 70     | 438     | 1.2             | 15    | 69    |
| Total Suspended Solids (TSS)    | 0.07               | 22   | 92  | 1.0             | 69     | 588     | 1.1             | 15    | 40    |
| Ammonia (NH <sub>3</sub> -N)    | 0.02               | 3.5  | 16  | 0.63            | 8.7    | 29      | 0.07            | 6.8   | 23    |
| Total Kjeldahl Nitrogen (TKN)   | 0.04               | 5.8  | 20  | 1.3             | 18     | 51      | 0.82            | 11    | 32    |
| Nitrate (NO <sub>3</sub> -N)    | 0.05               | 0.9  | 3.5 | 0.31            | 3      | 13      | 0.01            | 1.2   | 3.5   |
| Total Nitrogen (TN)             | 0.12               | 3.0  | 9.9 | 2.1             | 12     | 32      | 0.85            | 4.0   | 9.8   |
| Organic Nitrogen (OrgN)         | 0.02               | 1.8  | 5.7 | 0.74            | 5.6    | 18      | 0.71            | 2.1   | 3.2   |
| Total Phosphorus (TP)           | 0.01               | 1.2  | 4.4 | 0.27            | 4.1    | 11      | 0.09            | 2     | 4.2   |
| Dissolved Phosphorus (DP)       | 0.01               | 0.6  | 1.3 | 0.23            | 2.6    | 5.7     | 0.04            | 1.5   | 3.7   |
| Fecal Coliform (FC) (col/100mL) |                    |      |     | 1.7             | 73,000 | 360,000 | 47              | 1,320 | 9,800 |

Possible to attain Class B quality with filtration & disinfection

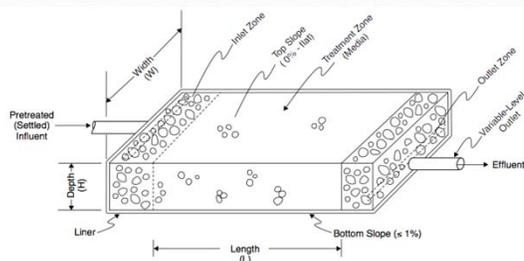
- Class B:

- TN = GWQA
- BOD<sub>5</sub> = n/a
- Turbidity:
  - 5 NTU daily arithmetic mean &
  - not to exceed 10 NTU
- TC:
  - 2.2/100 ml &
  - not to exceed 23/100 ml
- Be aware that temperature may be a constraint in NPDES permit

## Constructed Wetlands

• A VSB is typically composed of the following component sections:

- Pretreatment
- Inlet, coarse aggregate
- Treatment zone
  - Vegetated, or not
- Outlet, coarse aggregate
- Water elevation control structure
- Disinfection sys if required
- Effluent Dispersal method
  - Surface water discharge
  - Subsurface dispersal
  - Land application



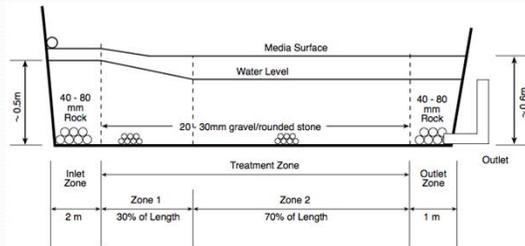
# Constructed Wetlands

• VSB have 1 configuration but yield different results depending on how they are operated:

- Continuous flow = Anaerobic
- Fill & Flush = Aerobic

• Fill & Flush will require:

- Outlet control works
- Inlet control works



# Constructed Wetlands

• VSB data

| Parameter               | System Influent | Wetland Influent | Wetland Effluent  |
|-------------------------|-----------------|------------------|-------------------|
| BOD (Total) mg/L        | 154             | 41               | 10                |
| BOD (Soluble) mg/L      | ND <sup>1</sup> | 21               | 8                 |
| COD (Total) mg/L        | 349             | 79               | 43                |
| COD (Soluble) mg/L      | ND              | 40               | 31                |
| TSS mg/L                | 132             | 59               | 7                 |
| VSS mg/L                | ND              | 39               | 5                 |
| TKN mg/L                | ND              | 5                | 3                 |
| NH <sub>4</sub> -N mg/L | ND              | 1.4              | 2.1               |
| Organic N mg/L          | ND              | 3.1              | 1.1               |
| NO <sub>3</sub> -N mg/L | ND              | 4                | 0.2               |
| TN mg/L                 | ND              | 9                | 3                 |
| TP mg/L                 | ND              | 3                | 4                 |
| Fecal Coliforms#/100ml  | ND              | TNTC             | TNTC <sup>2</sup> |
| DO mg/L                 | ND              | 2.4              | 1.8               |
| pH                      | 6.9             | 6.9              | 7.0               |
| Temperature °C          | ND              | 31.8             | 30.5              |

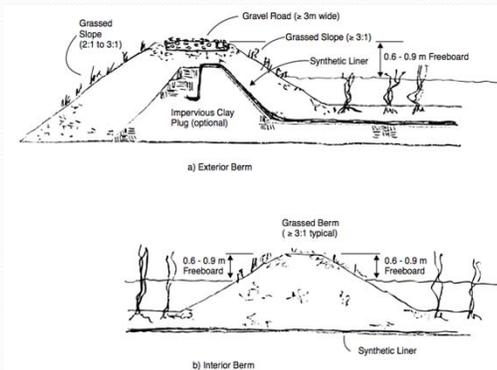
<sup>1</sup>ND = No data available.  
<sup>2</sup>TNTC = Too numerous to count, sample taken prior to disinfection

Possible to attain Class B quality with filtration & disinfection

- Class B:
  - TN = GWQA
  - BOD<sub>5</sub> = n/a
  - Turbidity:
    - 5 NTU daily arithmetic mean &
    - not to exceed 10 NTU
  - TC:
    - 2.2/100 ml &
    - not to exceed 23/100 ml
- VSBs typically yield lower temperatures, but not in this case

## Constructed Wetlands

- Liners:
  - Required
    - Synthetic
    - Engineered soil
  - Leak testing needed
    - FWS tested as a lagoon
    - VSB more complicated due to media over liner
      - Pre-consultation meeting strongly recommended
- Class A Recycled Water Lagoons (IDAPA 58.01.17.609.02)
  - Allows FWS construction without liner if Ground Water Quality Standards not violated



## Constructed Wetlands

- Liners
  - Natural or synthetic, it must protect the ground water & adjacent surface water from degradation.



## Constructed Wetlands

- CW were added to the approved list of WW technology back in the 2009 Rule revision.
  - IDAPA 58.01.16, “Wastewater Rules,” Section 455.04.g.i,
    - Allows use of passive WW treatment technologies for communities with flows less than 25,000 GPD
    - FWS and VSB are listed

University of Vermont,  
CW Research Center



## Constructed Wetlands

- Section 455
  - “Private Municipal Wastewater Treatment Plants”
  - This does not prevent Public Municipal Wastewater Treatment Facilities from using CWs.
- FWS and VSB configurations appropriate for:
  - Small communities
  - Polishing processes

Columbia, MO  
Pop: 108,500



## Constructed Wetlands

- What do you know or have heard about CWs?
  - Let's discuss 4 topics



Rockview SCI, PA

Prince George, BC



## Constructed Wetlands

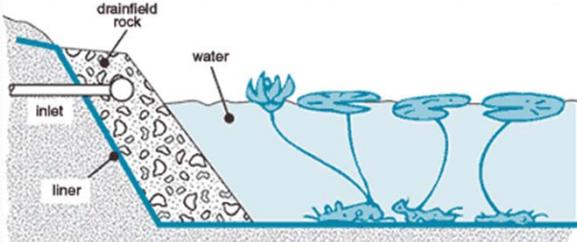
- Wetland design has been well-characterized by published design equations.
  - True Or False?
- FALSE
  - CW's complexity (biologically, hydraulically, & chemically)
  - Lack of quality data of sufficient detail (temporally & spatially)
  - Formulas have been developed from data sets compiled from very different sites (sampling methods, influent quality, climate, ...)
  - All of these factors lead to Uncertainty about the Validity of the Parameters used in the Design.

## Constructed Wetlands

- CWs are aerobic because plant roots supply oxygen.
  - True or False?
- FALSE
  - Early studies on fully vegetated CWs receiving 2ndary effluent implied oxygen transfer to roots in lightly loaded system – not the case in systems receiving heavier nutrient loads (municipal sys).
  - Field experience & research indicate that small amounts of leaking oxygen is insufficient to address municipal WW loading rates.
- Sources of oxygen other than wetland plant roots can be designed into CWs
  - FWS
  - Fill & Flush VSB

## Constructed Wetlands

- CWs can remove significant amounts of nitrogen.
  - True or False?
- IT DEPENDS
  - FWS vegetated sections & continuous flow VSB are anaerobic
  - Suitably designed FWS with open water zones can nitrify
  - VSB & FWS CWs can denitrify if they received nitrified WW



The diagram illustrates a cross-section of a constructed wetland. On the left, an 'inlet' pipe leads into a 'drainfield' consisting of 'rock' and a 'liner'. Water flows from the inlet into the drainfield. To the right, the water flows into a 'water' zone containing several plants with large, round leaves. The entire system is contained within a 'liner' at the bottom.

## Constructed Wetlands

- CWs can remove significant amounts of phosphorus.
  - True or False?
- FALSE
  - Initial sorption rates in FWS soil tapers off quickly
  - Minimal plant uptake compared to municipal loading rates
    - Seasonal uptake
    - Minimal in VSB due to aggregate size & minimal plant uptake

## Constructed Wetlands

- Why use CWs
  - Affordable
    - As long as municipality already has the land
  - Operable
    - Simple O&M requirements
  - Reliable
    - Properly maintained & operated CW can yield consistent effluent quality

## Constructed Wetlands

- Consequently, CW may be suitable for:
  - Small communities,
  - Private wastewater treatment systems (subdivisions)
- What final disposal methods are appropriate for CW effluent?
  - Subsurface disposal under Recycled Water Rules
    - IDAPA 58.01.17.615
    - Sized according to Subsurface Rules
    - Nutrient load reduced to at least domestic WW strength
  - Surface Water Discharge (NPDES permit required)
  - Land application (beneficial use under IDAPA 58.01.17)

## Constructed Wetlands

- FWS Pros/Cons

| ADVANTAGES                                   | DISADVANTAGES                                    |
|--|--|
| Creates wildlife habitat                     | Potential human & wildlife exposure to pathogens |
| Adds scenic & educational value to community | Burrowing mammals can be a problem (ex muskrats) |
| Good pollutant removal                       | Odor & mosquito production                       |
| Self sustaining system                       | May require vegetation management                |



## Constructed Wetlands

- VSB Pros/Cons

| ADVANTAGES                                      | DISADVANTAGES  |
|---|--|
| Quick startup                                   | Less aesthetic & wildlife value than FWS wetland           |
| Limited human contact with primary effluent     | Requires complicated operation to achieve nitrogen removal |
| Very few mosquito & other vector problems       | Higher cost of media & startup                             |
| Efficient removal of contaminants               |  |
| Better cold weather operation than FWS wetlands |  |

Rockview SCI, PA  
Before & After planting



## Constructed Wetlands

- Documents to submit
  - Facility Plan (also called a Master Plan)
    - IDAPA 58.01.16.410
  - Technical, Financial, & Managerial (TFM) Capacity
    - IDAPA 58.01.16.409 & 58.01.17
  - Preliminary Engineering Report (PER)
    - IDAPA 58.01.16.411
  - Location & Separation Distances
    - IDAPA 58.01.16 & 58.01.17
  - Plans & Specifications
    - IDAPA 58.01.16.420
  - Operations & Maintenance Manuals
    - IDAPA 58.03.16.425

## Constructed Wetlands

- Facility Plan (FP)
  - Update FP to ID impact system modification or addition will have on community
  - FP addresses system-wide growth, IDs deficiencies, & lays out the plan for system upgrades & expansion

Eversteekoog, Netherlands, Isle of Texel  
Tertiary treatment of 4000 m<sup>3</sup>/day (1.06 Mgalpd)



## Constructed Wetlands

- Technical, Financial, & Managerial (TFM) Capacity address:
  - The design, construction, O&M, & personnel requirements stipulated in Rule
  - Cash flow, revenue, bonding, financing, & fiscal controls
  - Ownership, management structure, Articles of Incorporation, By-Laws, covenants, procedures & policies for effective long-term operation
  - TFM in Recycled Water Rules (IDAPA 58.01.17.612) exempt new Class A facilities if owned by a Public Utility governed by the IPUC Rules (IDAPA 31.01.01)

## Constructed Wetlands

### Preliminary Engineering Report (PER)

- Required for new systems or one receiving a major modification where P&S review is required
  - Addresses Project specific topics including, but not limited to:
    - Purpose,
    - Scope,
    - Hydraulic capacity,
    - Treatment capacity,
    - O&M requirements



Eversteekoog, FWS cells

## Constructed Wetlands

### PER

- Must be provided for:
  - All major WW Collection System projects,
  - All Pump Station projects,
  - All Treatment Plant designs & upgrades, and
  - All Septage Transfer Stations
- Not required for:
  - Simple WW main extensions approved by QLPE



Eversteekoog Outlet Weir

## Constructed Wetlands

### Facility Location (IDAPA 58.01.16.450.01)

- Must be protected from 100-yr flood (450.01.b)
- 200 ft setback from property line for systems open to atmosphere near residences (450.01.c)
  - Possible reduced setbacks negotiable for areas zoned for commercial or industrial
- Lagoon location (IDAPA 58.01.16.493.05)
  - 2 ft minimum vertical separation from bottom of structure to:
    - Maximum ground water elevation (493.05.b)
    - Bedrock (493.05.c)

## Constructed Wetlands

### Facility Location

- VSB?
  - Constructed with gravel layer separating effluent from vectors & humans
  - Some VSB owners allow human traffic on designated pathways
  - Recommend discussing proposals with DEQ Regional Office during initial project consultation meeting



## Constructed Wetlands

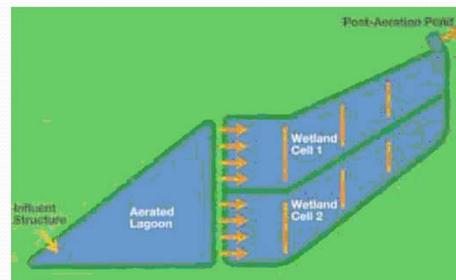
### Facility Location

- Subsurface Disposal (IDAPA 58.01.17)
  - Drain field sizing based on:
    - Nutrient loading
      - Should not exceed domestic wastewater strength as specified in Technical Guidance Manual (TGM), Table 3-1
    - Soil Type & application rate specified in TGM, Table 2-10
    - Effluent average daily volume
  - Setback distances should comply with Subsurface Rules (IDAPA 58.01.03.008.02.c & d, & .013.04.c & d)

## Constructed Wetlands

### Plans & Specifications (P&S)

- P&S submittal to DEQ
  - Sufficient detail to construct
  - Specify design criteria
  - Review forms
  - Appropriate construction permit applications
  - Require a PE stamp, dated & signed by Responsible PE.



## Constructed Wetlands

- Operations & Maintenance (O&M) Manual
  - Required for all WW systems, should include, but not limited to:
    - Daily operating instructions
    - Operator safety procedures, valve locations, & key system features
    - Parts list & order info
    - Responsible Charge Operator info
    - Trouble-Shooting section



## Constructed Wetlands

- O&M continued
  - Schedule of Maintenance activities, such as
    - Check weir settings, & inlet & outlet structures
    - Remove nuisance species (muskrats, gophers)
    - Remove sediment from forebay



## Constructed Wetlands

- List of references for design of CW:
  - US EPA, 2000. *Guiding Principles for Constructed Treatment Wetlands: Providing for Water Quality and Wildlife Habitat*. Washington, D.C., EPA 843-B-00-003, 41 p.
  - US EPA, 1999. *Constructed Wetlands Treatment of Municipal Wastewaters Manual*. Washington, D.C., EPA/625/R-99/010, 165 p.
  - US EPA, 1999. *Free Water Surface Wetlands for Wastewater Treatment, A Technology Assessment*. Washington, D.C., EPA-832-S-99-002

## Constructed Wetlands

- US EPA, 1993. *Subsurface Flow Constructed Wetlands for Wastewater Treatment, A Technology Assessment*. Washington, D.C., EPA-832-R-93-008
- Vymazal, Jan, 2005. Horizontal sub-surface flow and hybrid constructed wetlands systems for wastewater treatment. *Ecological Engineering* 25, 478-490.
- Crites, R., Tchobanoglous, G., 1998. *Small and Decentralized Wastewater Management Systems*. McGraw-Hill, Boston, MA

## Constructed Wetlands

- Questions?